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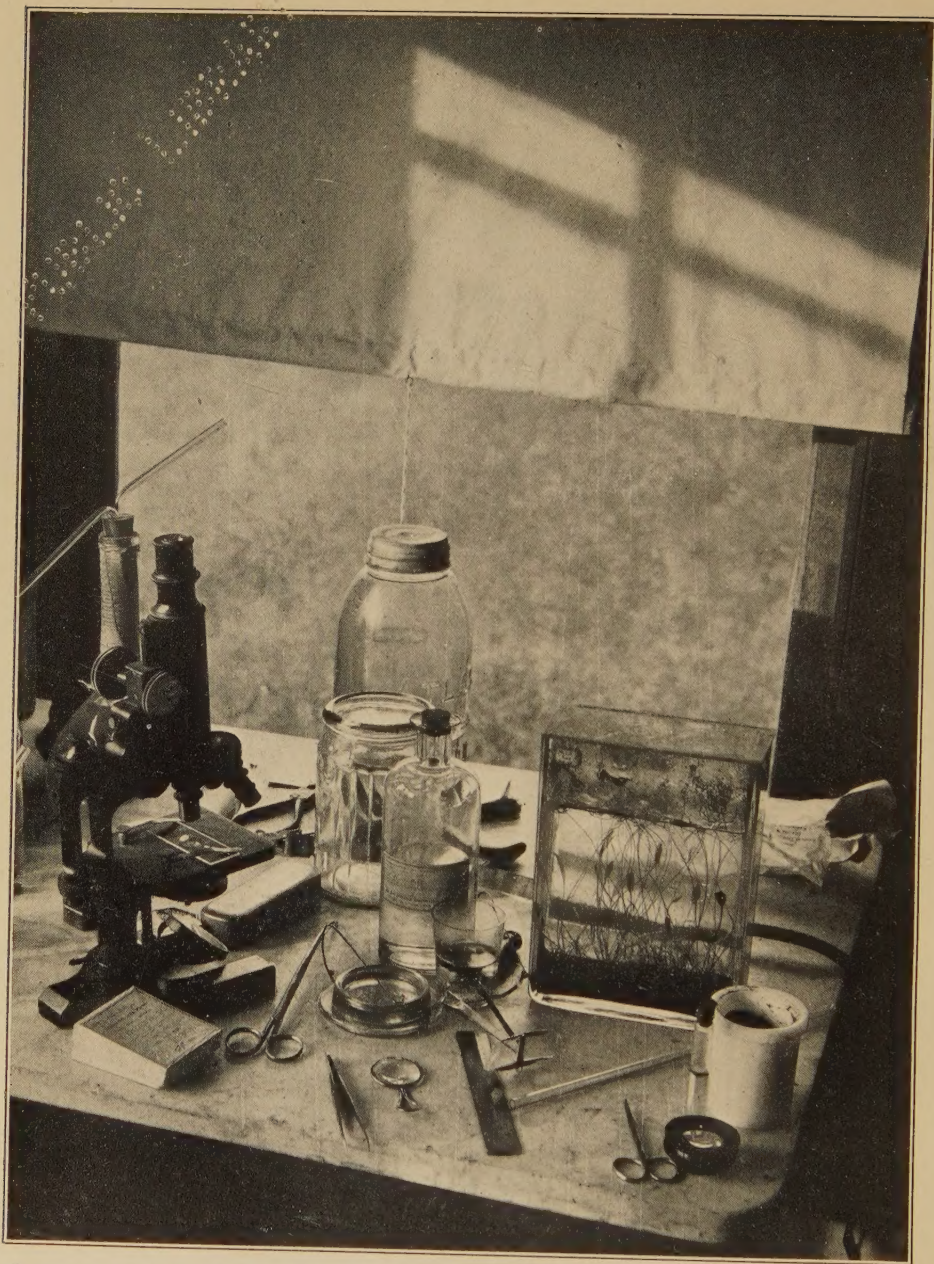


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A corner of the author's study showing the One-quart World at the right, between the white jar and the bottle. (Chapter VI.)

BACKYARD EXPLORATION

BY

PAUL GRISWOLD HOWES

*Curator of Natural History at the Bruce
Museum of Natural History, History
and Art, Greenwich, Conn.*



ILLUSTRATED WITH 216 PHOTOGRAPHS
AND DRAWINGS BY THE AUTHOR

GARDEN CITY
DOUBLEDAY, PAGE & COMPANY
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FIRST EDITION

DEDICATED TO

THAT GREATEST OF ALL SPIRITS,
WHICH RESTORES THE MIND IN
SORROW, BRINGS CONSOLATION
IN ADVERSITY, AND FOR ITS
PRICELESS GIFTS OF HAPPINESS
AND HEALTH ASKS NO REWARD,
THE GREAT OUT-OF-DOORS

PREFACE

To fill a gap in nature literature and to illustrate the possibilities of exploration at home are the chief reasons for this book. The title is intended to convey the "At home" idea and does not refer to the actual limits of my own backyard, or that of anyone else, but rather to a considerable area of territory about my home in Connecticut.

When I commenced to be seriously interested in natural science, I felt the need of a condensed volume of facts regarding the common living things about me other than birds and mammals, a book wherein one might find adequate portraits of familiar or newly discovered creatures from microscopical dwellers of the pond to the highly organized reptiles. My desired book would inform me briefly about the smaller denizens of my territory, and would, in more specialized chapters, point out the possibilities of studying single species.

This is the gap that I have tried to fill with *Backyard Exploration*, for, as far as I am aware, there is no other book of its kind. It is, of course, far from complete and could not well be otherwise in a single volume, but I hope that it makes plain the field which is open to the explorer at home.

I have tried to give the work a practical value, rather than to use too much space in colourful stories. Contacts at the Museum, with visitors of all descriptions have proved conclusively that an immense number of people wish to know only what a thing is called and a few additional facts concerning it, whereas the more seriously interested student would rather find out most of them himself. Because of these conditions, I have included chapters of condensed facts along with much more detailed studies, the latter for the special purpose of showing what may be done with any common thing. There is so much of interest at our back doors that the great problem has been to keep the book within bounds as regards its size.

The useful field might appear very limited at first glance because nearly everything sheltered within these covers has been found and studied within a tiny area of Connecticut, but this area, lying, as it does, in the very centre of an unusually rich faunal territory, puts quite another light upon the matter. The *territory* is limited but the application of the book is not, and it will serve as a guide and a mine of graphic visual knowledge over a large part of the East.

In a few instances, foreign things have been mentioned, but these have only been discussed for the purpose of shedding more light on particularly interesting phases of nature. Some of the chapters have appeared before as magazine articles, but most of the material is quite new.

Scientific names have been given throughout the volume for these are far more important than the common ones, but no attention has been paid to classification except in certain chapters. In a general way, the organisms have been grouped from lowest to highest, but otherwise species have been treated in a manner that to the author would appear most helpful to the person looking for information. Thus, for instance, the common fishes found in ponds and streams have been grouped together in one chapter, while those of the brackish inlets, or the salt water just beyond, have been grouped in another.

The illustrations represent a great amount of time and effort spent in the field and someone else will have to judge the results.

In conclusion, I hope that *Backyard Exploration* will serve as an aid to the vast outdoor army. A field must exist for this book, and if it helps to keep the fire of enthusiasm burning among Backyard Explorers, and even partly fills the gap alluded to, it will have fulfilled its purpose.

PAUL GRISWOLD HOWES.

Greenwich, Connecticut.

September, 1926.

CONTENTS

CHAPTER	PAGE
I. A DESCRIPTION OF THE AREA INCLUDED	I
II. REMINDERS OF THE ICE AGE	6
III. THE SIWANOYS, FIRST PEOPLE OF THE TERRITORY. .	10
IV. A CALENDAR OF NATURAL EVENTS	18
V. MICRO GARDENING	28
VI. A ONE-QUART WORLD	32
VII. THE EARTHWORMS	41
VIII. A FEW INVERTEBRATES OF THE SEA	45
IX. BARNACLES, SHRIMPS, AND CRABS	50
X. THE COMMONER MOLLUSKS	60
XI. OUR FRIENDS THE SPIDERS AND MILLIPEDES	76
XII. HOW I PHOTOGRAPH INSECTS	80
XIII. HOW TO STUDY AND PHOTOGRAPH ANTS	86
XIV. PARASITISM, NATURAL CONTROLLER OF NUMBERS . .	90
XV. FUNGUS DISEASES THAT DESTROY INSECTS	94
XVI. THE WASP ON THE WINDOW SILL.	97
XVII. THE HUMAN SIDE OF ANTS.	101
XVIII. THE LIFE AND HABITS OF THE BLUE AND YELLOW DAUBER	105
XIX. THE WATER TIGER	112
XX. OUTLINES OF INSECT LIFE HISTORIES.	115
XXI. INSECT ASSOCIATION ON A ROSE BUSH	131

CHAPTER	PAGE
XXII. SOME COMMON FISHES OF SALT AND BRACKISH WATER	135
XXIII. THE TWO- AND FOUR-SPINED STICKLEBACKS . . .	147
XXIV. THE ANGLER OR FROGFISH	151
XXV. MUMMYCHOG OR KILLYFISH	154
XXVI. SOME COMMON FISHES OF FRESH WATER	158
XXVII. A WORD ABOUT SALAMANDERS	173
XXVIII. THE FROGS AND TOADS OF THE TERRITORY . . .	182
XXIX. OBSERVATIONS ON TURTLES	192
XXX. SNAKES, FAMILIAR AND OTHERWISE	195
INDEX	203

LIST OF ILLUSTRATIONS

A corner of the author's study showing the One-quart World · *Frontispiece*

FIGURE	FACING PAGE
1. Rocks lying on the beach near Shippan Point that have been planed by glacial action	2
2. A tooth from the great rasp planed like fancy moulding	2
3. A boulder dropped in a field by the passing glacier	2
4. How kettles are formed	3
5. The making of New England hills	3
6. Smooth pebbles and stones taken from a cone, or "Till-island"	10
7. A pot-hole at Stamford, Connecticut	10
8. A Siwanoy kitchen midden	11
9. Removing the layer of stones that covered the refuse in the midden	11
10. Two rubbing stones and an ear ornament	14
11. The kitchen midden laid bare	14
12. Bones and teeth from the Siwanoy kitchen midden	15
13. A fragment of Siwanoy pottery	15
14. Examples of Siwanoy stone arrow points	15
15. The head of a House Mouse	18
16. The Tree Cricket in the act of singing	19
17. Fowler's Toad	19
18. A Petri dish of prepared medium exposed to the air four minutes grew these colonies	26
19. Another dish exposed four minutes after sweeping the hall	26
20. Plate of jelly exposed four minutes in a crowded theatre	26
21. The salmon-coloured mould	27
22. A photomicrograph of the black Mucor mould of bread	27
23. Tiny true plants thrive in the micro soil-garden	30
24. Tiny cups and fruits and knobs, and mere pin points of pigmented things	30
25. The One-quart World as it looked at the age of three years	31
26. Life of the One-quart World	37
27. Life of the One-quart World	38
28. Life of the One-quart World	39
29. An Earthworm and its recent casting	42
30. An Earthworm, much enlarged, showing the swollen clitellum, or egg capsule.	43

FIGURE		PAGE
31.	Marine invertebrates	46
32.	The Sun-jelly	46
33.	A common Starfish	46
34.	The Cake Urchin	46
35.	Surface of the Starfish	47
36.	Tube houses made of sand grains by the common Marine Worm	47
37.	Early stages of barnacles and crabs	51
38.	The common Barnacle	54
39.	The common Sand Shrimp	54
40.	The Blue or Edible Crab	54
41.	An enlarged photograph of a common small Mud Crab	54
42.	The Beach Flea and a Sow Bug	54
43.	The Fiddler Crab	54
44.	An enlarged view of the two surfaces of the Sow Bug	55
45.	The Water Asel	55
46.	Young Sow Bugs feeding on rotten wood	55
47.	Young Horseshoe Crabs	58
48.	Newly hatched and hatching Horseshoe Crabs	58
49.	Early stages of mollusks	61
50.	Fresh-water snails	62
51.	Common fresh-water snails	62
52.	Common fresh-water mollusks	62
53.	A common fresh-water mussel	62
54.	Common snails (Terrestrial)	62
55.	Common snails (fresh-water)	62
56.	The introduced slug	62
57.	The common slug	62
58.	A life-size picture of <i>Limax maximus</i>	62
59.	Marine mollusks	63
60.	Marine mollusks	63
61.	Eggs of the common snail	66
62.	The common Periwinkle	66
63.	The snail that constructs the familiar "sand-collars."	66
64.	Marine mollusks	67
65.	Marine mollusks	67
66.	Marine mollusks	74
67.	Marine mollusks	74
68.	The common squid	75
69.	Portions of egg capsules and young of a Periwinkle	75
70.	The eggs of a common spider	78
71.	A small and common spider of the backyard	78
72.	A Lycosid spider with her brood of young upon her back	78
73.	A young spider "ballooning"	78
74.	A brood of young house spiders just bursting forth into the world	78

LIST OF ILLUSTRATIONS

xiii

FIGURE		PAGE
75.	Living forms found beneath a stone	78
76.	A common centipede in houses	79
77.	A common red centipede	79
78.	A small bee photographed in the glass box	82
79.	The Potter-wasp	82
80.	A larval, or young Rove-beetle attacking a worm	83
81.	The Monarch Butterfly	86
82.	A small predacious fly photographed in the glass box	86
83.	A Robber Fly	86
84.	The glass formicary or ant hive, ready for making photographs	86
85.	Carpenter Ants in the act of battling	86
86.	The interior of an ant colony photographed by means of the glass formicary	87
87.	A group of Aphis that have been parasitized	90
88.	Ichneumon parasite of the Cabbage Caterpillar	90
89.	A Cabbage Caterpillar with the larvæ of an Ichneumon	90
90.	Enlarged photograph of the cocoons made by an Ichneumon parasite of a caterpillar	90
91.	Parasites in larval form	91
92.	Mature Ichneumon parasites that issued from a single larva of the Mud-wasp	91
93.	Photomicrograph of parasitic Hymenopterous insects that issued from a larval wasp	94
94.	Megarhyssa, the long-tailed Ichneumon parasite of the Tremex	94
95.	Three galls found as fleshy growths upon leaves	94
96.	The chrysalis of a butterfly and a mummy caterpillar	94
97.	Two House Flies and a beetle that have been attacked by a fungous disease	94
98.	A large Black Ant killed by a fungus	94
99.	Another ant, curled up in death	94
100.	Wooden tablet tube used as a nest by <i>Odynerus unifaciatus</i>	95
101.	The wasp on the window sill, upon her tablet-box nest	95
102.	Part of the respiratory system of a larva of <i>Sceliphron cementarium</i>	98
103.	Later stage in the larva of <i>Sceliphron cementarium</i>	98
104.	A single fat cell, showing its contents consisting of numerous drops of fat	99
105.	An X-ray photograph looking through a living larval wasp	99
106.	Carpenter Ants resting upside down	102
107.	Young ants in a nursery	102
108.	A warrior Army Ant showing its huge mandibles	102
109.	An ant tending its "cattle"	103
110.	The common Blue and Yellow Dauber-wasp upon her nest	106
111.	Front and side view of cells of Blue and Yellow Dauber-wasp	106
112.	An opened nest of a Mud-wasp	107

113.	Detailed contents of sixty-seven cells of the wasp	108
114.	<i>Argiope transversa</i> , the Banded Garden Spider.	110
115.	<i>Argiope riparia</i>	110
116.	Four of the favourite spiders used as provisions by the wasp <i>Sceliphron cementarium</i>	110
117.	A Water Tiger attacking a young eel	110
118.	An egg of the Water Tiger	110
119.	A young Water Tiger waiting for its prey	110
120.	A full-grown larval Water Tiger sucking the juices of a tadpole	110
121.	The adult form of the Water Tiger	110
122.	Springtails in their world	111
123.	Nymphs of Dragon Flies	111
124.	The Dobson Fly	114
125.	The larva of the Ant Lion	114
126.	Life-history of the Ant Lion	114
127.	The Golden-eyed Lace-wing Fly with one of its curious, stalked eggs	115
128.	The fishing net constructed by the larva of the Caddice Fly	115
129.	A Caddice Worm in its tube house robbing another individual's house of building material.	118
130.	Houses constructed of various materials by Caddice Worms.	118
131.	A young Long-horned Grasshopper or locust	118
132.	A wingless, Long-horned Grasshopper	118
133.	One of the very few Oriental Mantids ever taken in Connecticut	118
134.	An Assassin Bug with its victim	118
135.	Butterflies hold their wings upright or spread flat when resting	118
136.	Spittle masses made by the young of Frog-hoppers	118
137.	The viviparous aphid	118
138.	Full-grown Tent Caterpillar about to make its cocoon	119
139.	The young of flies are maggots	119
140.	"Tumblebugs" are Scarab Beetles	122
141.	Some gall-making insects	123
142.	An Oak Gall	123
143.	Exterior of the galls as shown in Figure 95	126
144.	Gall found upon Hackberry, made by <i>Pachypsylla cucurbitæ</i>	126
145.	Spiny Rose Galls cut open to show the larvæ of the insect	127
146.	The Spiny Rose Gall, <i>Rhodites bicolor</i> , made by a small wasp-like insect	127
147.	An Ichneumon and a Bee come to the sweet exudations	130
148.	The dragon-like young of the Ladybug feeding upon the Aphids	131
149.	A great herd of sucking Aphids and group of the Ladybug's long yellow eggs	131
150.	A rambler leaf, showing pupæ of the Ladybug and newly emerged insect	138
151.	A number of Aphids containing Ichneumon parasites	138

LIST OF ILLUSTRATIONS

FIGURE		XV PAGE
152.	Head of the American Smelt	139
153.	Head of the Common Herring	139
154.	The Alewife	139
155.	The rare Copepod parasite of the Menhaden	142
156.	Young Eels	142
157.	The Spearing, Silverside, or "Sand Smelt"	143
158.	The Sea Horse	143
159.	A young Bluefish or "Snapper"	143
160.	Male Two-spined Stickleback and eggs	146
161.	Nest of a Two-spined Stickleback opened up to show the eggs	146
162.	New-born Two-spined Sticklebacks	147
163.	Four-spined Stickleback	147
164.	Cartilage "skeleton" of the "foot" of the Angler	154
165.	The Angler or Frog-fish	154
166.	Under surface of the Angler	155
167.	Foot-like fin of the Angler showing "fingers"	155
168.	A Mummychog	158
169.	Head of a Mummychog	158
170.	Redfin or Shiner and Black-nosed Dace	158
171.	Hornyhead male from the Mianus River	158
172.	Head of Hornyhead showing crown of tubercles	158
173.	The head of the Common Sucker	158
174.	Young Eastern Brook Trout	158
175.	The Tessellated Darter	159
176.	Spawn of Small-mouthed Black Bass on stones	159
177.	The Marbled Salamander	174
178.	The Spotted Salamander	174
179.	Head of a Spotted Salamander	174
180.	Egg mass of the Spotted Salamander	174
181.	Eggs of the Spotted Salamander.	174
182.	Red-backed Salamanders	174
183.	The Red-backed Salamander, red phase	174
184.	The Red-backed Salamander, gray phase	174
185.	A female Red-backed Salamander, opened to show ten developing eggs	175
186.	A salamander at home in Sphagnum Moss	175
187.	The larval form of the Spotted Salamander	178
188.	A female Newt	178
189.	Front view of the American Toad	179
190.	Front view of Fowler's Toad	179
191.	Jelly egg strings of the American Toad	186
192.	Enlarged view of toad's eggs with developing tadpoles	186
193.	The Spring Peeper.	186
194.	Young tadpoles of the Wood Frog	187

FIGURE		PAGE
195.	The Common Tree Frog	187
196.	The Wood Frog	190
197.	The Leopard Frog	190
198.	The Green Frog	190
199.	Eggs of the Snapping Turtle	190
200.	Eggs of the Painted Terrapin	190
201.	The Snapping Turtle	190
202.	The Painted Terrapin	190
203.	The Spotted Turtle	190
204.	Eggs of the Spotted Turtle	191
205.	Embryo of turtles removed from the eggs	191
206.	The Wood Turtle	191
207.	The Ribbon Snake	194
208.	The Water Snake	194
209.	The Brown Snake	194
210.	The Black Snake	195
211.	Eggs of the Black Snake	195
212.	Greatly enlarged photograph of a Black Snake's egg	198
213.	The Green, or Grass Snake	198
214.	The beautiful Ring-necked Snake	199
215.	Immature Hog-nosed Snake	199

BACKYARD EXPLORATION

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CHAPTER I

A DESCRIPTION OF THE AREA INCLUDED

THE area encompassed by *Backyard Exploration* is roughly that territory which lies within a circle ten miles in diameter and whose central point is the city of Stamford, Connecticut. It must be understood that the creatures described and photographed in this book extend over wide ranges, and to interested persons the volume will therefore serve as a guide covering much of the Eastern territory. The point to be remembered is that, with a very few exceptions, the species treated throughout the work have been *found and studied* by the author within the narrow confines of this ten-mile circle.

Almost the whole state of Connecticut lies in what is known as the Alleghanian Zone. There are many zones known to the naturalist and these are characterized by the presence of certain physical conditions and certain *breeding species*. Other species which breed within the state and which are found along the southern border and in some of the river valleys belong to the Carolinian Zone, which shows that the district is within the northern limits of this zone also. Besides this, for instance, a few of the birds characteristic of the Canadian Zone are found breeding in the northern portion of the state, which shows a Canadian element near by.

The ten-mile circle is primarily Alleghanian, but the breeding of the Fish Crow, Acadian Flycatcher, White-eyed Vireo, Chat, Blue-winged Warbler, and Orchard Oriole—the latter two, commonly—gives a pretty strong Carolinian colour to the area.

Part of the border of the state, within the circle, faces Long Island Sound, and this shore is therefore shut off to some extent from some pelagic species that might otherwise be found.

The coast of the region is a succession of salt marshes, sandy beaches, bays, and inlets. These extend for short distances inland, where low, rolling hills replace them, rising higher as one progresses northward. None of the hills within the circle are much more than five hundred feet above the level of the sea, but toward the northern part of the state they become much higher, and in Bear Mountain, which is 2,354 feet in altitude, the highest point is encountered.

The hills within the ten-mile circle are covered by thin soil and masses of rock, and many are well forested, while the intervening valleys are often swampy or covered with tangles and woodlands, growing from a rich soil. Ponds and brooks are numerous, but none of the streams are large ones. The woods are chiefly deciduous, but cedars are common and large groves of virgin hemlock are still standing, especially along the streams between the ridges north of Stamford.

The larger rivers of the state, the Thames, the Connecticut, and the Housatonic, are outside of the area, and we have only such streams as the Rippowam, the Mianus, and the Noroton.

The whole area shows the distinct alterations brought about by glaciation. A mantle of *débris*, consisting of more or less smoothed stones and boulders, broken and crushed rock fragments, is everywhere apparent. Meadows are often studded with big boulders, while balanced boulders are not entirely absent on rocky ridges where they were left by the melting ice. There is a single example of a neatly bored pothole on the Stillwater Road near Stamford, made by a whirling stone in softer rock when strong water currents flowed down this valley, as the great ice sheet melted away, while extensive beds of gravel, shading from heavy material at the bottom to lighter stones and sand at the surface, indicate the localities of glacial wash.

The rocks of the region are interesting and numerous. A dark micaceous sub-porphyrific and porphyritic¹ formation of rock, often containing hornblende, occupies some space in Stamford and Greenwich and extends along the Sound from the east side of Stamford harbour into New York State. Varieties of this rock occur between the Byram and Mianus

¹Characterized by the presence of distinct crystals in a fine-grained base. These are sometimes an inch long in local rocks.

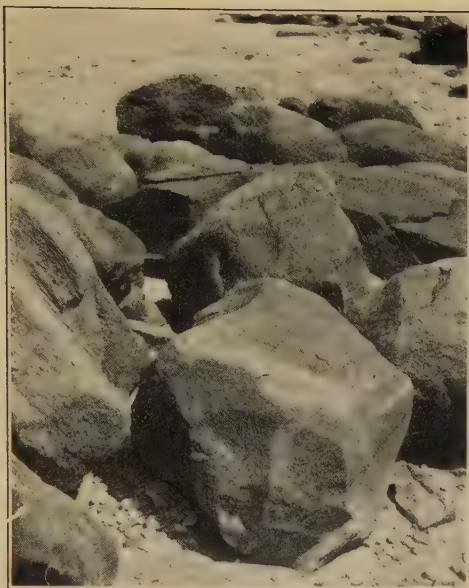


Fig. 1. Rocks lying on the beach near Shippan Point, that have been planed by glacial action. Note the distinct facets.



Fig. 2. A tooth from the great rasp planed like fancy moulding. Such interesting objects lie about often unnoticed.



Fig. 3. A boulder dropped in a field by the passing glacier.

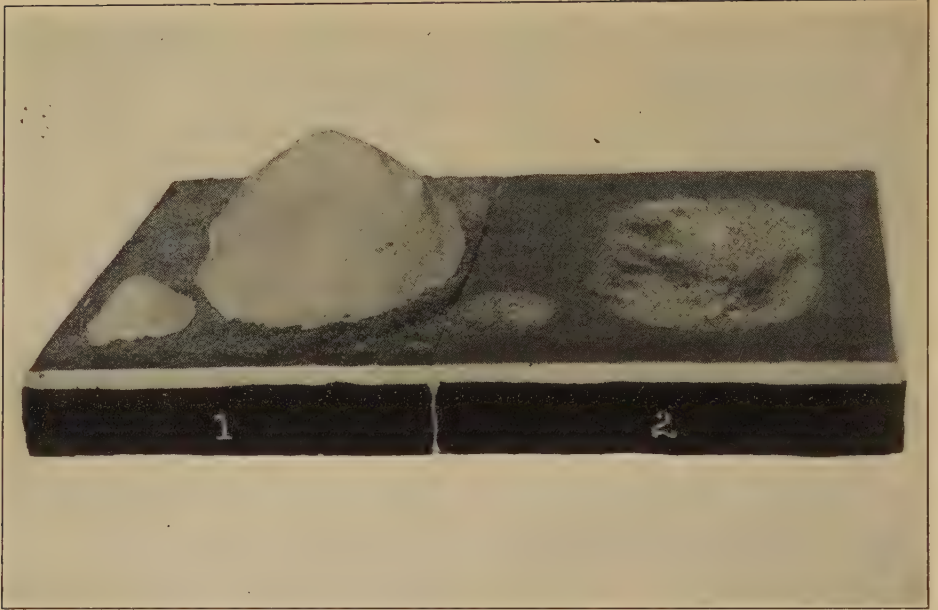


Fig. 4. How kettles are formed. (1) Shows two huge blocks of partly buried ice. (2) Shows the resulting kettles caused by the melting of this same ice. From a model prepared by the author.

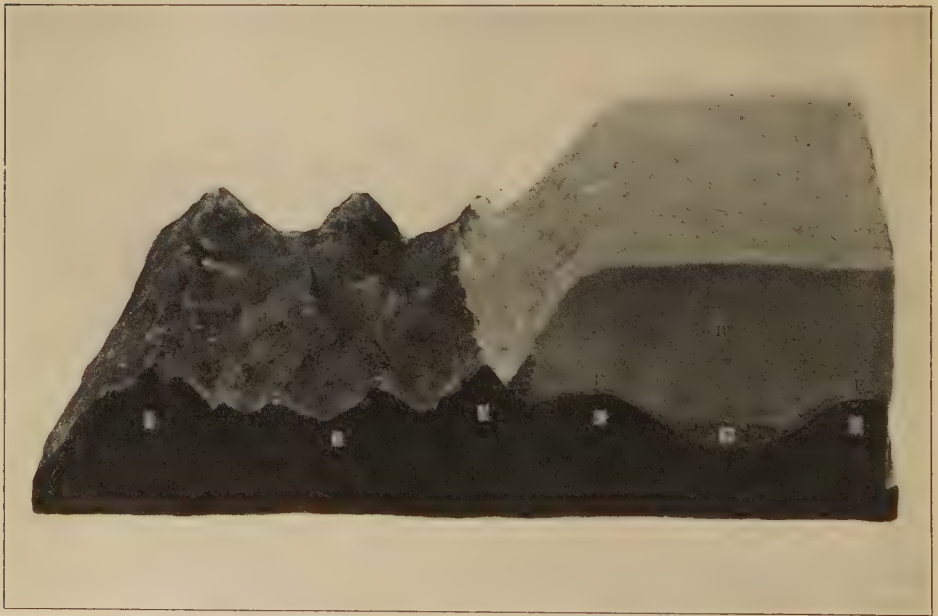


Fig. 5: The making of New England hills. (B) represents the great ice sheet planing off the mountains (A) and filling the valleys with debris (D). The result being the rounded hills (C). (E) is the mantle of debris carried upon the bottom of the glacier. From a model prepared by the author.

rivers. Still another variety formerly quarried to some extent in Greenwich is lighter gray and more or less striped with feldspar and dark mica.

North of Stamford is a thicker, bedded rock, light bluish gray, porphyritic and similar to the last type mentioned. Granite-gneiss of coarse grain was also quarried at Greenwich, while west of Stamford is a series of beds of coarse white granite alternating with micaceous rock which contains many garnets. Dark green hornblende is not uncommon, and a sienitic variety of this seems to be found only west of the Noroton River. It is thick and massive and breaks into trap-like blocks.

Adjoining the valley of the Noroton River and extending in the direction of New Canaan, there are coarse-grained dark rocks sometimes with green talc and included masses of granite with red feldspar. A nearly black micaceous schist, with small veins of red and white feldspathic granite and asbestos-hornblende, extends in places along a valley opening northeasterly from the valley of the Mill River, near North Stamford, north of New Canaan.

South of Darien are small tracts of porphyritic and sub-porphyritic rocks similar to those of the Greenwich formation. A range of rock (granitic) varying from white to gray may be traced from north Greenwich, through Stanwich and Long Ridge, where in the latter village it crops out behind the house on the farm formerly owned by Charles L. Howes. In the same direction east of the Mill River in Stamford and north of the valley extending northeast from North Stamford, already referred to, another isolated range of granitic gneiss bears northeast into Ridgefield, where it ends.

A dark green hornblende schist occurs in the northern part of Greenwich, and also considerable gneiss formations characterized by dark or light gray, striped micaceous rock of fine grain and soft lustre. It is associated with other rocks, including limestone, which is found northeast of Byram River to Byram's Pond. Limestone also occurs here and there in the Mianus valley, from Bedford, New York, southward.

These few notes on the geology of the area in which my studies have been made may be of value, but they are far from complete, and are only intended to give a general idea of what is to be found.

In addition to the rocks, there are some other interesting minerals.

Garnets are very common, associated with the rocks, and may be found almost anywhere. The stones in the characteristic walls around our fields are very good places to look for them, and they may be easily separated undamaged by breaking up some of the material in which they are imbedded. Cassiterite (tin oxide) is very rare in my experience, but I have found it twice at Long Ridge.

Iron pyrites is occasionally found, and the iron ore Limonite, from which red and yellow ochre is made, is not uncommon. This ore occurs in large lumps or in more flattened and eroded masses and it is often mistaken by the layman for meteoric iron, which it does somewhat closely resemble.

The climate is quite severe during the winter months, because of the extreme variation of temperature from day to day and the general uncertainty of weather conditions from year to year during this season.

Our winters may be snowbound and icy with little let-up in cold and precipitation, or like 1924-25 which was very mild with little snow until late in the winter.

The severity of our winters has definitely affected certain species. A familiar case is that of the Carolina Wren, a bird that has repeatedly tried to establish itself with us, and although successful in summer, has found our winters too severe.

Our springs are often cool and rainy, but when the weather once becomes settled, no more healthful and pleasing conditions could be found anywhere. From late May or early June until November, there are not many of us who will complain. There is no state that surpasses the Nutmeg for abundance of life forms or the beauty of its natural scenery.

I cannot imagine any selected area that would give the biologist more diversified types of ground for his work than the one in which it has been my good fortune to live. The waters of the Sound, the beaches, brackish inlets and salt marshes, the rolling hills and meadows, ponds and streams and swamps, the rocky ridges, tangled groves and woodlands afford suitable shelter and food for a host of living creatures. If one spent his entire lifetime in this limited area, its possibilities in biology would be far from exhausted.

In this tiny region I have spent many of the best days of my life, and

while I love the jungles and far places of the earth with a born love, I often sit among these native hills, soaked with water and mud and the joyous dirt of smaller explorations in ponds and fields and forests, experiencing supreme minutes and hours, for no reason, except, perhaps, that the sky is clear, the valleys mauve with soft vibration, and my whole being attuned to the moods about me.

And so came my inspiration for *Backyard Exploration!*

CHAPTER II

REMINDERS OF THE ICE AGE

TO MANY of us, glacial scars are common sights. It is, however, undoubtedly true that less than one person out of every thousand realizes the significance of these signs when he sees them. They lie about our fields and houses, along our railroads, everywhere, in fact, in the land that the great glaciers visited. To explain the character of a few of these things is the purpose of this brief chapter. It is one thing to appreciate the beauties of Nature, but a greater joy lies in interpreting her products. These lie strewn about us. Nature's huge open book only awaits the appreciative reader, and her free library may occupy one for a lifetime.

It is startling to realize at the outset that the ice sheets reached a maximum thickness of ten thousand feet in many parts of the country over which they travelled. Such masses of compacted ice covered parts of all the Northern states at various times in the past, leaving, in their passage or retreat, an indelible record.

Our New England states were vastly altered by the coming of these glaciers. Their true character lies disfigured and buried beneath a heavy blanket of *débris*. Some of these states were originally mountainous, but are now made up of rounded hills. As the ice moved forward with all its terrific power and weight, the tops of these mountains were sheered off before the irresistible force, as if by a gigantic plane.

Valleys were thus filled with *débris*, and later, when the ice melted, the country was changed completely. Rounded hills filled the place of mountains, their wounds showing as naked places that are our granite quarries of to-day. (Fig. 5.)

The mantle of *débris* that covers glaciated land is best seen in railroad cuts, where it has been necessary to blast a passage through the older rock of the country. We see this mantle as a layer of sand, smooth peb-

bles, and stones of all sizes and descriptions, lying over the older rock below. In gravel pits we see this also, often laid down in layers becoming lighter in the weight of their material as we ascend, showing that the deposits were probably laid down under water, as huge masses of ice melted.

Glaciers carried every conceivable size of stones from minute sand grains to enormous boulders. These very travellers lie distributed in the wake of the glaciers, in meadows, on hillsides, along the beaches, and balanced as huge rounded boulders upon other more or less smooth rock surfaces over which the melting ice sheets passed.

In the bottom of the glaciers these imbedded stones formed a gigantic rasp that ground and gouged everything beneath them. Softer rock surfaces were scratched and gouged like butter by the harder stones of the rasp, and often the teeth themselves were planed like samples of fancy mouldings. In the New York Zoological Park, in New York City, is one of the most wonderful examples of gouged rock to be found anywhere. Here the larger teeth of the rasp cut long deep channels throughout the length of the softer material, the smaller teeth made grooves and slight scratches, while the sand and very fine material polished the entire slab almost as though a buffing wheel had done the job. This wonderful sight lies exposed in the ostrich cage, unnoticed by most of the park visitors. Sometimes we find such an exposure with scratches and grooves that run in two directions across its surface, telling of the passage of two distinct masses of ice.

Such smoothed surfaces as this, even though unscratched, are usually due to the former passage of ice, if they be found in the country over which the glaciers spread. I know of a huge mass of porphyritic granite that lies in front of the house of a Stamford citizen, where it was dropped by the ice and left, so smoothly planed that the crystals of orthoclase within it appear as though cut with a sharp-edged knife. In back of the same house and equally unappreciated is a fine specimen of ground rock, a tooth from an ancient glacial rasp.

In Connecticut, glacial signs are everywhere, for here the ice was nearing its journey's end. What caused it to melt eventually, no one seems to have explained in a satisfactory manner, but where the melting took

place we see another interesting result of glaciation. We might call these signs "Till-islands," or cones, as is really proper.

Within the glacier, as we have seen, were great quantities of worn sand, smooth pebbles, and stones, which were gradually concentrated as the ice melted. All this material eventually reached internal streams and was finally expelled through vents along the outer walls of the ice mass. Wherever these streams found their outlets, the sand and stones were poured out, and here they banked themselves against the side of the glacier. Now, as melting progressed, its retreat caused these banks to tumble backward, thus forming more or less cone-shaped groups of small hills. These stand up above the surrounding land in many places and may be recognized by their contents of sand and finely smoothed stones of all sizes. Some of these stones are polished and almost round, and I have wondered if the Indians used them as ready-made implements.

Many masses of ice became more or less deeply imbedded with sand and other wash accumulating about them. These masses naturally melted last, owing to their protection from the sunlight. When at last the temperature became sufficiently high to melt them, the débris about them naturally fell inward from all sides, thus forming holes whose banks are made up of worn pebbles and stones, and upon the bottom of which large boulders are found just where they melted out of the ice. Such holes sometimes became ponds and lakes in later times or even small bays opening into deeper water. (Fig. 4.)

The holes are known as kettles. The small lakes among the hills of Long Island, for instance, and fresh-water ponds such as Lake Ronkonkoma owe their presence to melting ice of the glacial period. Some typical examples of various kinds of kettles may be seen on Long Island, which is a Paradise for the student of glaciation. Lake Success, two miles south of Manhasset, is one. Another is Great Pond, just south of Riverhead, while a third is Poxabogue Pond, a mile east of Bridgehampton.

Toward the close of a glacial period, when the ice commenced to melt in earnest, floods occurred and formed rivers that would dwarf many of our largest ones to-day. So great were these torrents that enormous boulders were rolled along like pebbles, and thus transported miles and miles beyond their original positions. Some of these, caught by a turn of fate

upon a submerged mass of softer rock, were whirled about by the waters, until at last they bored themselves deeply into the softer stuff. Some are found to-day, high and dry, mere rounded fragments of their former selves, in the bottoms of deep symmetrical circular wells. Others ground themselves away altogether, leaving potholes in the solid rock, as evidence of what took place.

Thus, wherever the great ice masses existed, they left their history clearly written. For hundreds of years these signs, of which I have mentioned but a handful, lay uninterpreted, a fascinating record of a phase of the earth's history. Only recently were they recognized in this country as identical with the marks and scars which the great existing glaciers of Europe are making to-day. To Agassiz we owe our recognition of glacial records in America. It only remains as a great wonder, owing to the readable character of these ice scars, that no man before Agassiz realized their significance.

CHAPTER III

THE SIWANOYS, FIRST PEOPLE OF THE TERRITORY

ASCANT six hundred years ago, what is now the territory occupied by Stamford and Greenwich, Connecticut, and the intervening suburbs, was a wild and beautiful forest that stretched its sheltering arms from the interior of the country to the very beaches and lapping waves of our loved Long Island Sound. Through this scented forest roamed a magnificent wild life, a heritage that we have shamefully lost. In the cool stream waters that wound beneath virgin hemlocks lurked a finned people that to-day struggle for existence in the hardening arteries of their empire. In the forest-bordered bays and inlets in spring and fall, myriad wild fowl winged down to the voices of brethren, feeding at dawn on the sweet young mussels of the tide pools and water lines, while the painted skies silhouetted V's of migrant geese whose deep calls told of changing seasons. There were no sharp sounds to disturb the air, no din of civilization clad in steel and the vapour of steam, only the sun, the whispering, wordless voices of trees, the silence of the starry skies, and the curling perfumed smoke of wigwam fires.

Shippan Point supported an Indian village. Stamford itself was Rippowam, a larger village, but in 1642 someone from New Haven changed its good Indian name. Down by Greenwich resided other Redskins, and the story goes that they sold all their territory from that town up to and including what is now Sound Beach for a few cots and blankets and the early wherewithal of a new civilization. This was back in 1640, and their old chief Ammogoronne signed the deed.

Motorists by the million pass the old Indian Field Road each year. It branches off from the Post Road about a mile east of Greenwich and leads one straight south to the blue waters of the Sound. Its name is at once suggestive, but how few of us care to set out upon adventures that so suggest themselves.



Fig. 6. Smooth pebbles and stones taken from a cone, or "Till-island."



Fig. 7. A pothole at Stamford, Connecticut.



Fig. 8. The sight of a few protruding oyster shells in this newly cut driveway led to the discovery of a Sivanoy kitchen midden.



Fig. 9. Removing the layer of stones that covered the refuse in the midden. Some of these may be seen at the right.

Every day, on my way to the museum in Bruce Park, I travel over this byway. It is rough and bumpy and often icy in winter, and always I see the rolling ground peopled once more with wigwams and the incoming Siwanoy braves and hunters bearing the deer, the wild fowl, and other good things of the time. I see the glowing embers and the blue wood smoke of fires; the squaws with their home-made earthen pots. I smell the savoury perfume of maple sap turning to sugar and hear the laughter of the children at their games.

For a time, I went away to South America, and upon my return, some months later, several new houses had been constructed on the Indian Field Road. This I regretted very much indeed, for I had missed the thrill that a prospective cellar-digging always gives me, for it is just such things that bring hidden secrets to light.

Sometime later, still another house was contracted for, and as the gateway was being dug from the main road to the house, there came to my delighted eyes a sight that I had hoped for for many years.

A few oyster shells, nothing more; but at the sight of them protruding from the earth in this gateway, my heart all but stopped with excitement. A few minutes of scratching and digging convinced me that at last I had found a kitchen midden of the Siwanoy, a refuse dump, that is all, but one in which there would be some message of the past, facts about our own Siwanoy, of whom history is extremely fragmentary.

Permission being granted by the interested landowner, I was soon at home arranging for the excavation of my find. There were sieves to be constructed, a truck to be commandeered, and an excited Irish gardener to be calmed and assured that there would be no pots of gold, nor "bones, ill luck, and misfortune" in the midst of the shell heap.

We dug very carefully from above, down through the rich black earth that had been the forest mould in days of yore. The way led through the root system of an ancient tree. We removed one root six inches in diameter and a little later our shovels struck rock. We tried a new place with the same result, and another and another, and so came the first revelation, that these Indians had placed a layer of stones over the refuse before filling in the hole with dirt. This stone layer lay upon the topmost shells, approximately two and one half feet below the surface of the ground.

Removing the stones, we then bored a hole through the refuse, until the earth was encountered again. At the side, the dump was three feet deep. It was later found that the sides of the pit sloped toward the centre, and here it reached a depth of nearly four feet with a uniform diameter of a few inches more than six feet. The land had originally sloped gently to the west, but the road's having been cut through in a southerly direction had left a bank, which contained the refuse pit. A quarter of a mile west of the road is a lake, extending from the railroad embankment near Greenwich through the woods almost to the Boston Post Road near the foot of Putt's Hill. On the south, a half mile distant, is the inlet at Coscob, and all the Sound lies beyond, so this camp site of the Siwanoy was indeed favourably situated. At their backs the forest extended for who knows how far? Game and fish and wild things were everywhere, and they had only to step from their wigwams to find them.

The first thing of interest to be uncovered, after the layer of stones, was a tooth. Not a human tooth, but that of a deer, the same species that roams our woodlands to-day. The tooth rolled down the growing load in the truck. My brother picked it up and, almost as he did so, others came to light, still contained in a fragment of cracked jaw bone. As we dug in, other bones of all sizes were found. Being large, they were easily seen, and all were of an aged orange colour. Aside from these things, relics of age-old feasts, nothing was found until the sifting and screening commenced with the aid of water power.

Every bone had been cracked open with stone hammers, as marrow was greatly relished by the Indians. Even the tiniest ones, if marrow bearers, had been so treated, and many fragments were rounded and smooth as though they had been gnawed and sucked until only mineral matter remained.

Late in the afternoon the precious heap of rubbish lay safely in boxes and automobiles. The gateway lay in utter ruins, but the generous interest of the owner would not even allow of our fixing it up again. The hole was simply filled in, and we were off for home and the aid of water and sieves.

Under this treatment, almost the first washings revealed a small fragment of pottery, part of the upper portion of a baked clay cooking uten-

sil. Its slight curve showed that it had been of considerable dimensions, seven inches in diameter at the mouth, the rim of which had been decorated with a scalloped design while the clay was still soft. The fragment bulged toward the bottom so that the pot was probably twelve inches in diameter at its widest part, and its surface below the scalloping had been decorated further with a series of indentures, close together, running around the pot, one row below the other. (Fig. 13.) Many other smaller fragments were found, all showing traces of fire, except one yellowish bit from a jug of different pattern, very crudely decorated.

Quantities of bone were found, and a few fragments caught in the smaller sieves below. Here were small bird bones, fish vertebræ, and the lower arm of a lobster claw. Most interesting of all was a beautifully sharpened bird bone with a hole drilled through one end. This was an Indian needle!

Now came charcoal from fires of long ago, then a round rubbing stone for finishing off the finer stone weapons, and two beautiful though imperfect white quartz arrowheads, imperfect because this was a rubbish heap. There were many fragments of quartz and chips discarded in the making of stone implements, all of great interest to the searchers.

As the work progressed, three more arrow points were found, one of long, narrow dimensions and the other two broken in halves. Of special interest was another rubbing stone, brick-red in colour and less than two inches in length. The sides of this implement tapered somewhat as if to afford a convenient hold for the fingers, and the stone shows small scratches over two surfaces, while the smallest end of it has been ground into many facets of uneven sizes by some technical use of the past. (Fig. 10.) The prize of the whole discovery came on the third day of washings in the form of an arrow point of deep chrome yellow quartz. It was an unfinished weapon showing much chipping up to a point near the centre of the object, and here work had ceased, leaving a raised, rough portion of stone. (Fig. 14.) This arrow point is unlike any in the museum collection.

A great many more cracked bones and deer teeth and jaw fragments were now recovered; then, on the fourth day, in the last shovelful to be washed, a fragment of an ornament, most likely an ear decoration, was

found. It was fashioned from a very thin piece of slate and had been pierced at its narrowest end by a stone drill. This ended the valuable list from the refuse.

Taken as a whole, 90 per cent. of the refuse consisted of oyster shells of all sizes. About 5 per cent. was made up of scallop shells, 3 per cent. round clams, and the rest small shells of salt-water mollusks and the relics already described. The oyster shells were very crumbly, but those of the clams and scallops were sound and strong. The smaller shells were those of the common snail, *Alectrion obsoleta*, and the Oyster-drill, *Urosalpinx cinerea*. Having mentioned these mollusks, figures of them may be seen in Chapter X by anyone interested.

However little may be interpreted from the things which my excavations brought to light, I consider it a duty that I should piece together what I can and bring the result to the attention of people, in published form. When we stop to realize that these splendid tribes have passed forever from our part of the world, and that no one apparently lifted a finger to chronicle their ways and manners for the benefit of generations to follow, whatever we now run across in their forgotten camp sites should be intensively studied.

Not until the fires were out and the odour of roasting game had gone forever, when there were nothing but ghosts of a vanished race, did men realize how shamefully they had neglected their duty.

Here is the best I can do with my meagre material. My Indians of the Indian Field Road were the Siwanoy, a subdivision of the Mohican tribe that occupied the Sound up as far as Norwalk. They were of Algonkian linguistic stock and a tribe of some culture. It is hard to realize that northern America was then in the Stone Age, for that seems to imply thousands rather than hundreds of years ago; yet all of our North American Indians were in the height of that age when the settlers arrived.

The refuse tells us that these Red men subsisted chiefly upon shellfish because shellfish were easy to obtain in great abundance all along the shores near their villages. Fish were caught, together with lobsters and other marine creatures, but not so frequently. The shellfish were dragged up at all ages, stones and all, in the case of the smallest oysters, for there were quantities of tiny oyster shells attached to stones in the refuse.

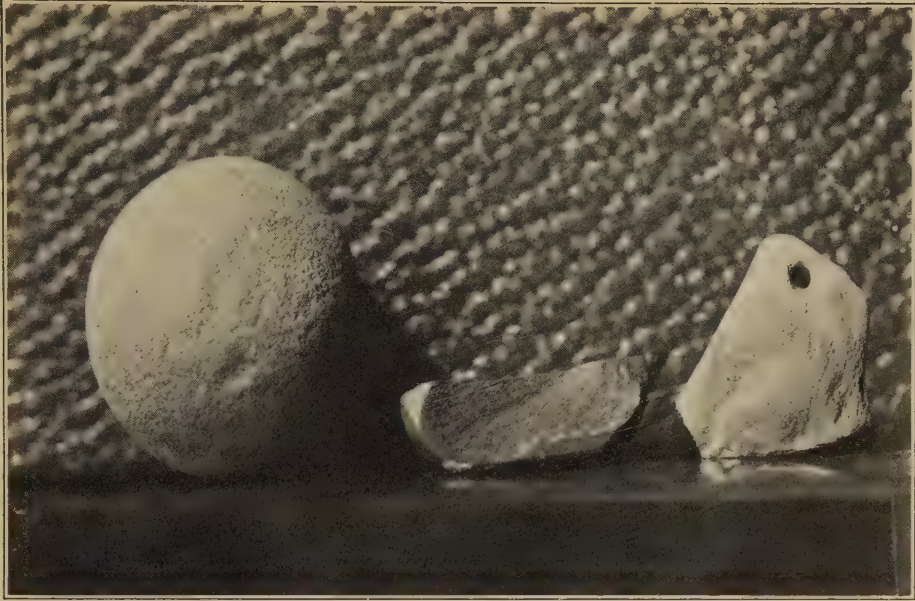


Fig. 10. Two rubbing stones and an ear ornament. The stone in the centre is the red one with the ground facets.



Fig. 11. The kitchen midden laid bare, showing the vast quantity of shell.

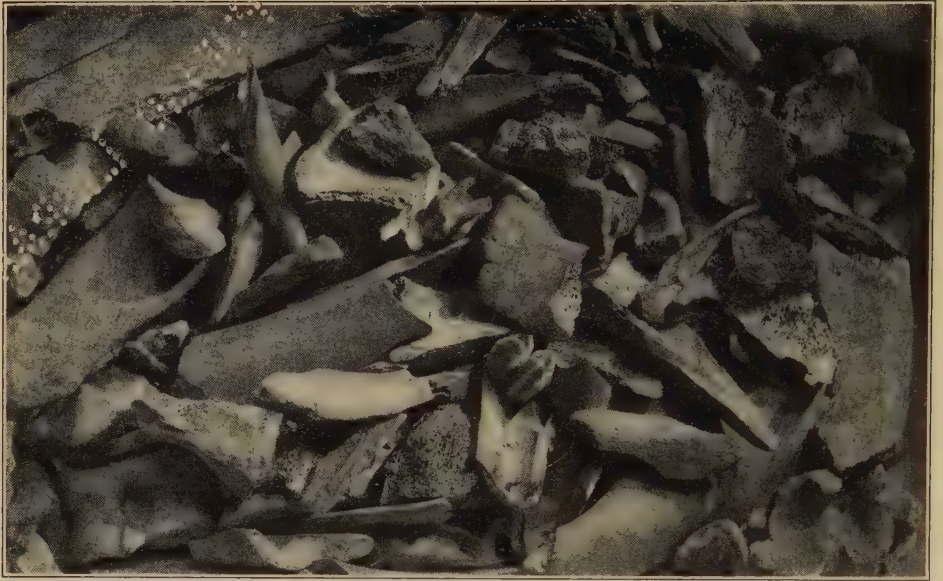


Fig. 12. Bones and teeth from the Siwanoy kitchen midden. Most of these have been cracked open to obtain the marrow.



Fig. 13. A fragment of Siwanoy pottery showing the interesting design. An ear of corn may have suggested this pattern.



Fig. 14. Examples of Siwanoy stone arrow points found in the Indian Field Road midden. The point of yellow quartz is shown in the centre.

Animals such as the deer were very successfully hunted, while small birds were less often obtained. There was no waste in these camps. Every bone was cracked and gnawed and stewed, and its nourishment assimilated to the last atom, and then some of them were fashioned into needles and other implements of domestic use.

To obtain their game, the men fashioned their arrow points of quartz, the only local mineral, apparently, that was satisfactory. For their celts and more highly prized possessions, almost any hard stone would serve because these were rubbed and ground to a high finish anyway, and a stone that was but roughly chipped might end as a highly polished weapon.

Pottery was made from brown or yellow clay into which finely pounded stone was kneaded for added strength, while the exteriors of the vessels were neatly patterned while soft, and then baked in such a manner as to produce splendid cooking and storage pots. The Siwanoy could draw crudely, as is proved by a fragment of a pot found at Stamford some years ago that was impressed with a part of a bird. Stone drills were possessed for boring holes in stone implements and in shell used for wampum.

In making their arrow points, a bit of quartz was struck repeatedly until a fragment suitably shaped was obtained. Chips of all sizes attested the work which followed the preliminary operations. The artisans must have been very particular about their arrows, because those found in the refuse were in some cases neat examples that, to the excavators, appeared plenty good enough to shoot any kind of large game. One point of dark gray stone, quite at variance with the others, may have been imported from another tribe, or snatched from a slaughtered enemy.

What I have told is not a great deal, but it is fact and not vague conjecture. Here, on this road in Greenwich, I have had the pleasure of definitely establishing the exact location of a Siwanoy camp site.

All along this road grow magnificent elm trees, very old elms of statuesque proportions, but they must have been unborn when the Siwanoy lived below. To the west was the forest, now partly destroyed by a development company. To the south lies the Sound. It, only, remains as the Indians saw it; everything else is new and changed.

Where did the Siwanoy go? What swallowed and obliterated them so completely? Perhaps there are a few mixed bloods still in the state, but part of the great Mohican tribe to which they belonged wandered to Indiana, others went to Pennsylvania and were lost track of, and still other bodies ended in New York and Wisconsin. No one cared.

Besides this shell heap, I have come across many other signs of the people that preceded us. Only recently another shell heap was destroyed and the refuse carted away and lost. This midden lay near the foot of a mass of rock that overlooks the Mill River, south of the Diamond Ice Company's plant and just to the right of the Post Road as one travels toward New York from Stamford. It was destroyed and taken away before I could arrange to secure it.

In the woods near Scott Cove, at Noroton, I found two rock shelters in the winter of 1924. One, a well-formed cave, contained bones, some potsherds (one with a remarkable design), and a fragment of a celt that may have been broken in battle at this very spot. The other shelter was merely the face of a sloping rock and may have been but a place for cooking. Here I uncovered part of a clay smoking pipe and numerous portions of a single large cooking pot, together with considerable shell.

Along the Mianus River, I have picked up stone implements, as have the natives of the country districts. In Sound Beach, in 1923, one of the finest caches of stone scrapers that I have ever seen was unearthed when the foundations of a garage were being laid. Here were 125 argillite scrapers of beautiful workmanship. These may have been traded and hidden. They were most like the scrapers that were made at Trenton, New Jersey, and probably had their origin there, as there is no argillite like this material in this locality. Most of these objects may be seen in the collection of the Bruce Museum at Greenwich.

At Coscob there is the old camp site where Chief Coscob pitched his tepee, and in Greenwich, the burial place of another chief. Ponus Sagamore is buried, and the spot marked by a stone pillar, at Ponus Ridge. He was the Sachem of the tribe known as the Rippowams. He died in 1640.

The Pequot swamp, where one of the bloodiest of Indian wars came to an end, lies near by, although it is outside the territory covered by this

book. It is marked by a monument and may be seen from the Boston Post Road.

At Pound Rocks at Stamford, near the old Cove Mills, Mr. William C. Banks has found numerous stone implements that prove this to have been a site where much manufacturing of stone artifacts took place. This was evidently a manufacturing site of the Siwanoy.

I believe that one has only to search diligently in our locality in order to locate other important Indian sites and the relics left in them by the great people that have passed on.

The last of the local Indians was doubtless Old Hardy, who lived in Greenwich. This old Indian made baskets for a living, and the children of another generation would cross the street in fear when he made his appearance in the town. The hole where he fished and the site of his home are well known to old residents. Old Hardy died sometime after 1850 and was buried at the town's expense, but no stone or mark was ever erected over the last of the Siwanoy, and so they passed forever from this locality.

CHAPTER IV

A CALENDAR OF NATURAL EVENTS

THE following calendar gives the dates of important nature events as they occur in the territory covered by this book. These may, of course, fluctuate somewhat from year to year, or even in a single season, according to the temperature and other physical conditions, but usually, in normal seasons, they will give the investigator information as to the time to be on the lookout for certain important things.

If one reads this calendar through rapidly from start to finish, he will experience the sensation of having seen a motion picture of the nature year. The picture starts calmly, with little or no activity, but as the reel progresses with the year, the whole thing speeds up in one's mind until the unfolding story becomes almost confusing with its numbers of characters and their activities. The climax is reached, as the reader progresses, and the picture slows down again, ending in December, almost as calmly as it began.

I have made calendars in this fashion in various places and countries. If one does this, such records will remain of unending interest to their compiler. Reading them over in later days will instantly give an accurate picture of seasonal activities in any locality that has been chosen.

Many of the events given in the calendar are described in detail in the remainder of the book, and the index may be used to advantage in looking for further information regarding something that has been found in the calendar.

CALENDAR OF EVENTS

January

- 1 Springtails (*Collembola*) active and numerous on surface of unfrozen ponds.
- 3 Black-crowned Night Herons will be found wintering in hemlock groves.



Fig. 15. The head of a House Mouse, *Mus musculus musculus* Linn. This greatly enlarged portrait gives some idea of the real beauty of this unpopular little rodent.



Fig. 16. The Tree Cricket in the act of singing. The sound is produced by rubbing the wings together. They sing only at night. Much enlarged.



Fig. 17. Fowler's Toad *Bufo fowleri* Putnam. A common but little seen member of our Amphibia. (See Chapter XXVIII.)

- 5 Golden-eye Ducks feeding in holes in frozen ponds.
- 8 If weather is severe, Redpolls and Pine Siskins will be found. Look around honeysuckle vines.
- 10 Purple Finches, White-throated Sparrows, Juncos, Nuthatches, and Chickadees swarm to food shelters.
- 15 Ducks come to inland waters to gather the tiny sweet *Pisidium* "Clams." Their tasty meat and weak shells making ideal food and grinding material.
- 18 Gray Squirrels feed through January on the abundant seeds of hemlock cones.
- 21 Look for Ruffed Grouse around barberry bushes in the woods.
- 28 Beach Flies (*Phycodromidæ*) are not unusual on beaches exposed to the sun. On mild days they will be found feeding upon refuse.
- 31 Another animal that is active all winter is the Short-tailed Shrew. Common near salt water.

February

- 1 Water Asels active in ponds and brooks.
- 5 Water Asels with eggs in pouches under legs.
- 12 Song Sparrows tuning up on warm days.
- 15 Black-crowned Night Herons take advantage of warmer days to catch sluggish Killies around edges of inlets.
- 20 Crows performing courtship antics.
- 22 Some hibernating animals stir themselves, if it is warm.
- 25 A general stir is noticeable among the resident birds.
- 28 If unusually mild, we may hear the songs of returning spring issuing from the Song Sparrows and Meadowlarks. Skunk Cabbage in full bloom.

March

- 1 The tops of the trees are hazy pink with swollen buds.
- 2 Robins and Bluebirds sometimes as early as this date.
- 3 If warm, more Robins, perhaps small flocks. Bluebottle flies appear in sunny places. Midges appear and dance over melting snow.
- 4 English Sparrows commence to build.

- 6 Peepers are heard as early as this date on rare occasions.
- 8 Flocks of Robins. Grackles in small flocks and singles.
- 10 Snow sometimes halts the awakening of things.
- 12 Occasionally a Red-backed Salamander may be found as early as this date.
- 15 Crocus two inches high. More flocks of Grackles.
- 16 Jonquils with big buds. Hemiptera (bugs) appear in protected places.
- 17 Insects become more numerous.
- 21 Peepers usually heard about this date.
- 23 Red-winged Blackbirds appear in their usual haunts, only males being seen at first. *Vanessa antiopa*, the Mourning-cloak Butterfly, appears at noon if the day is warm.
- 24 Water Striders come out of the mud. *Grapta comma* Butterfly appears.
- 25 Rhubarb well up. Downy Woodpeckers drilling holes for future nests. Red-backed Salamanders with well-formed eggs.
- 27 Stickleback (two-spined) courting in inlets.
- 30 Newts gathering in ponds. Small ant colonies with first batches of spring eggs.

April

- 1 Painted Turtles come out. Elders blooming. Moss fruiting.
- 3 Wood Frogs in ponds mating. Peepers numerous and easily caught at night with a flashlight. Tent Caterpillars hatch.
- 4 Cowbirds.
- 5 Phœbes. Great Blue Herons. Thunderstorms sometimes.
- 6 Blacksnakes come out to sun themselves. Toads mating and singing in swamps.
- 10 Elms in bloom.
- 12 Lycosid Spiders mating under stones and bark. Red-backed Salamanders very common.
- 15 Peeper Tadpoles hatch from early eggs. Maples in full bloom. Phœbes building.
- 17 Caddice Worms gather in dense groups on stones in streams. Red-shouldered Hawks with eggs.

- 18 Spotted Salamander egg masses common in ponds near woods. Many with well-formed embryos.
- 20 Bumblebees and other small bees abundant.
- 21 White-bellied Swallows. Mourning Doves nesting. Saxifrage and Adder's Tongue in bloom.
- 22 Green Herons arrive. Anemones and Cinquefoil bloom.
- 23 Barn Swallows and Golden-crowned Kinglets.
- 27 House Wrens sometimes as early as this date.
- 28 Large flocks of migrant Swallows.
- 29 Robins lining nests.
- 30 Spotted Salamander eggs hatch. Shad Bush blooms.

May

- 1 Spotted Sandpipers, Catbirds, Baltimore Orioles, and Blue-winged Warblers.
- 4 *Papilio turnus*, the Tiger Swallowtail, appears. Two-spined Stickleback eggs with large embryos.
- 5 Purple Trillium, white violets, blue violets in profusion.
- 7 Great influx of summer birds, Warblers, Vireos, etc. Bats feeding around street lights at night. Eggs of Stickleback hatch.
- 10 *Melitæa phaëton*, the Baltimore Butterfly's larva, is pupating.
- 12 White-eyed Vireos singing in thickets where they will nest.
- 15 Newts breeding.
- 16 Eels two inches long abundant in brackish inlets. Others five inches long feeding on Sticklebacks' eggs.
- 19 Small-mouth Black Bass with freshly deposited eggs. Fallfish and Tessellated Darters with eggs half formed.
- 20 Marriage flight of Termites.
- 21 Spittle masses made by Spittle Bugs common in grass.
- 23 Bullfrogs out. Great numbers of small Crane Flies emerge from salt meadows.
- 24 Full sets of Blue-winged Warbler eggs.
- 25 Broods of Minnow fry in brooks. Pheasants with fresh eggs. Damsel Fly nymphs getting ready to leave water.

- 26 Lilacs still blooming in late springs. Some varieties in height of bloom at this date and frequented by Dusk-flying moths.
- 27 Locusts in full bloom. Song Sparrows hatch first brood of young.
- 30 Rose-breasted Grosbeaks with finished nests. Crested Flycatchers building. Thalessa, the long-tailed Ichneumon Fly, drilling trees infested by Tremex.
- 31 Black-crowned Night Herons with young able to fly. *Melitæa phaëton* hatches. Large numbers of Wood Nymph Butterflies appear along woodland borders. The Water Bug, *Benacus griseus*, carrying eggs upon its back.

June

- 1 Golden-eyed Lace-wing Flies appear. Red-eyed Vireos building. Fowler's Toads singing and mating at night. (Fig. 17.)
- 4 Newts' eggs nearly ready to hatch. Young Water Bugs hatch from eggs on old ones' backs.
- 5 Tree Toads ascend trees from breeding pools.
- 6 Io Moths hatch from cocoons.
- 10 Young Milk Snakes of previous autumn ten inches long. Syringas in bloom.
- 11 Lycosid Spiders again with young on their backs.
- 12 Crowds of new-born fry of the Spearing in the inlets. Fiddler Crabs appear and make burrows.
- 15 Wood Frog tadpoles transforming into tiny frogs.
- 17 The large Ichneumon parasite of the Tent Caterpillar now emerges from its host, drilling a round neat hole through the cocoon.
- 19 Moths of the spring brood of Tent Caterpillars hatch, mate, and deposit new egg masses.
- 21 Great numbers of minute Fiddler Crabs appear.
- 23 Toads complete their metamorphosis in thousands.
- 25 Blue Crabs appear in inlets. The Mud-wasp, *Sceliphron cementarium*, building nests.
- 26 Large broods of Pyralidæ in salt marshes. Also broods of big Green-eyed Horseflies in the same habitat.
- 28 Shrimps with large egg masses.

- 30 Mummychogs spawning in Eel Grass in enormous numbers. Spear-
ing fry become more numerous, travelling in fast swimming schools.

July

- 2 Peeper tadpoles completing metamorphosis every day now.
4 Scorpion Flies deposit strings of eggs in ground.
5 Black Aphids appear in dense crowds on nasturtiums.
7 Snapping Turtles lay eggs.
8 Tree Toad tadpoles with legs budded. Great Robber Flies courting
and mating.
9 Baltimore Orioles with well-grown young. *Lycæna comyntas*, the
little tailed Blue Butterfly, appear in numbers.
10 Privet in bloom.
11 Horseshoe Crabs with embryos of large size.
12 Basswood blooms and bees reap a harvest.
13 Flies which live in Moth Mullein emerge.
15 Woods are filled with young birds. Wrens with second sets of eggs.
16 Eggs of the Horseshoe Crabs hatch. Vast broods of Mummychogs
also appear in inlets.
17 Cicadas.
19 *Sceliphron cementarium* (Mud-wasp) building activities in full
swing.
20 The Cicada Killer Wasp, *Sphecius speciosus*, appears, captures, and
stores its burrow with Cicadas for its young to feed upon.
22 Sumac in full bloom, and bees reap another harvest.
25 *Chlorion ichneumonea*, *Monobia quadridens*, *Spex urnaria*, and other
wasps in large numbers drinking nectar from the sumac blossoms.
Most of them are intoxicated.
27 Meadow Grasshoppers begin singing full songs at night.
28 Amblycorypha katydids singing.
29 This is the height of the butterfly season. Along the country roads
bordered by Milkweed and other flowering things in profusion will be
found butterfly hosts freshly emerged from their pupæ.
30 Daddy-long-legs come into the lights at night. The Diatom, *Clos-
terium moniliferum* var. *concaum*, one of the most beautiful of all,

becomes very abundant at this date in ponds. It is crescent-shaped and brilliant green.

August

- 1 Locust songs become more general in salt meadows.
- 2 Horseshoe Crab young reappear after their first disappearance. They now measure about seven millimetres in length and their tails have appeared.
- 3 Common Terns come back from breeding grounds. Summer apples are ripe.
- 4 Most bird songs have ceased. Wood Pewees, Song Sparrows, and Red-eyed Vireos still continue, however. Goldfinches, on the other hand, are nesting.
- 5 Baby Bluefishes (Snappers) are running. Virginia Creeper blooms. Snowy Tree Crickets now mature and commence to sing at night. (Fig. 16.)
- 7 Choke cherries and elderberries are ripe. Birds in moulting plumages come to feed on them.
- 8 Blue Crabs are now numerous and some are mating.
- 9 Embryos of the Wood Turtle half formed in eggs.
- 11 Herring Gulls return from the breeding grounds. Fish Hawks also come about the inlets and bays.
- 12 Eel Grass blooms.
- 15 Spotted Salamander larvæ changing to mature form.
- 18 Cardinal Flower blooms.
- 22 Young Blacksnakes emerge from eggs.
- 26 Migrations of Milkweed Butterflies sometimes.
- 27 Spotted Turtles deposit eggs.
- 28 New brood of small Crane Flies on the salt marsh. Insect life at its zenith, the nights are filled with their songs.
- 30 Goldenrod blooms freely.

September

- 1 The small blue Digger Wasps are now busiest. Least Sandpipers appear in flocks.

- 2 Mackerel commence to run.
- 3 Red-eyed Vireos are the only birds still singing regularly.
- 4 Yellowlegs and small warblers migrating.
- 5 Oil Beetles, newly emerged broods of Paper Wasps, and Coach Weevils flock to Goldenrod.
- 7 Much activity among the birds. Transients arrive together with summer residents that have nested north of us, and crowds depart for the South.
- 11 Nighthawks depart. Goldenrod at its height.
- 12 Visitation (1923) of a vast migration of the Cotton-worm Moth, *Alabama argillacea*.
- 13 Most of summer birds have left.
- 14 Red-eyed Vireo still feeding fully-fledged young, and the Least Flycatcher on rare occasions still has young in the nest this late.
- 16 New England asters and everlastings blooming everywhere in dry situations.
- 17 Small flocks of Black Ducks.
- 20 Great schools of Herrings and Alewives sometimes enter the inlets.
- 22 Redstarts migrating with other warblers. Last of the Mud-wasps working.
- 24 Second marriage flight of the orange "Stink-ants" since spring.
- 26 Dogwood berries feed the Robins and Starlings.
- 27 The Chain-streak Moth, *Cingilia catenaria* Drury, appears in numbers some years.
- 29 Wild Asters at their height.
- 30 Good crops of mushrooms may be gathered from pastures.

October

- 1 Peepers calling again in weak voices before hibernating.
- 3 Large migrations of minute spiders.
- 5 Juncos come back from the North.
- 7 Frosts silence the insect voices at night.
- 8 The night air is filled with bird voices as they migrate.
- 9 Golden-crowned Kinglets and White-throated Sparrows arrive from the North.

- 10 Bumblebee Flies come into houses and cellars to hibernate.
- 12 Song Sparrows still singing rarely. Insect voices pipe up during the warmth of day.
- 14 Poison Ivy turns fiery red.
- 16 Wild Asters still in full bloom unaffected by early frosts.
- 18 Yellow-bellied Sapsuckers arrive.
- 22 Yellowlegs still migrating.
- 24 Gentians at their best.
- 26 Orion at its best.
- 30 A few Bumblebees are feeding on Wild Aster honey on warm days.

November

- 1 Flocks of migrating Bluebirds visit the Poison Ivy berries.
- 2 Winter Wrens appear.
- 3 Ice on ponds.
- 4 Witch-hazel in bloom, the latest of the shrubs to flower.
- 5 On warm days spiders are ballooning by thousands, spinning out silk until it carries them off through the air.
- 7 Numbers of female Fall Canker-worm Moths appear.
- 8 Great Blue Herons still fishing in inlets.
- 15 Smelts running in inlets.
- 20 Great numbers of male Canker-worm Moths appear and hunt for the wingless females.
- 25 Canker-worm Moths laying eggs for the spring brood.
- 29 More large broods of Canker-worm Moths.

December

- 1 The red fruit of Sumac is visited by certain winter birds. Among these seeds are numerous insects, and these constitute the chief lure.
- 5 Pellets of bones and mouse fur upon the snow tell us that owls are about and that mice are active.
- 10 Partridge-berry is eagerly sought by the Ruffed Grouse.
- 15 Much insect life is still stirring. Under bark and stones, beetles

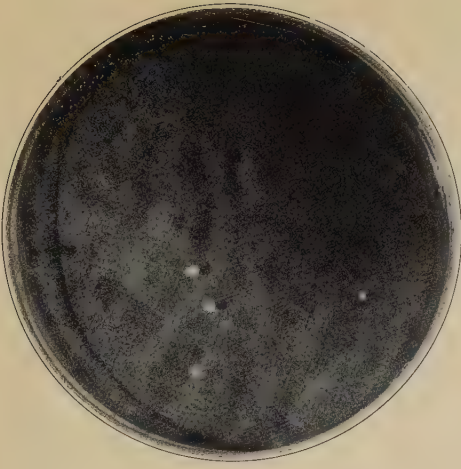


Fig. 18. A Petri dish of prepared medium exposed to the air four minutes grew these colonies.

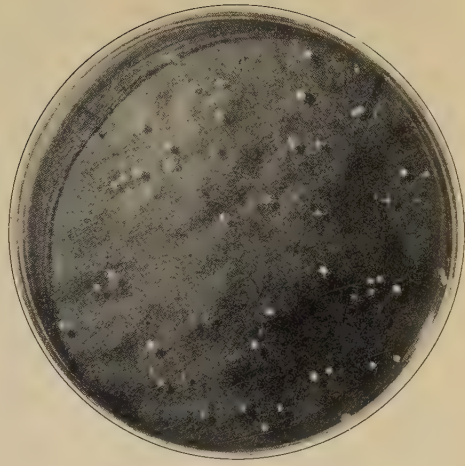


Fig. 19. Another dish exposed four minutes after sweeping the hall gathered this crop of micro weeds.

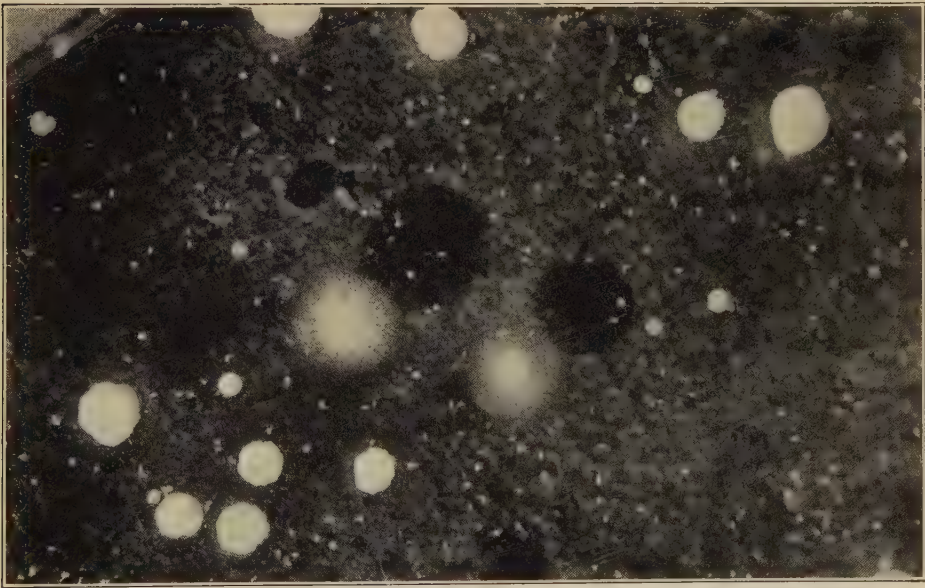


Fig. 20. Photomicrograph. This plate of jelly was exposed four minutes in a crowded theatre. The plain spots are colonies of bacteria and those with radiating threads are moulds.



Fig. 21. The salmon-coloured mould *Monilia sitophila* growing upon a moist bread medium.

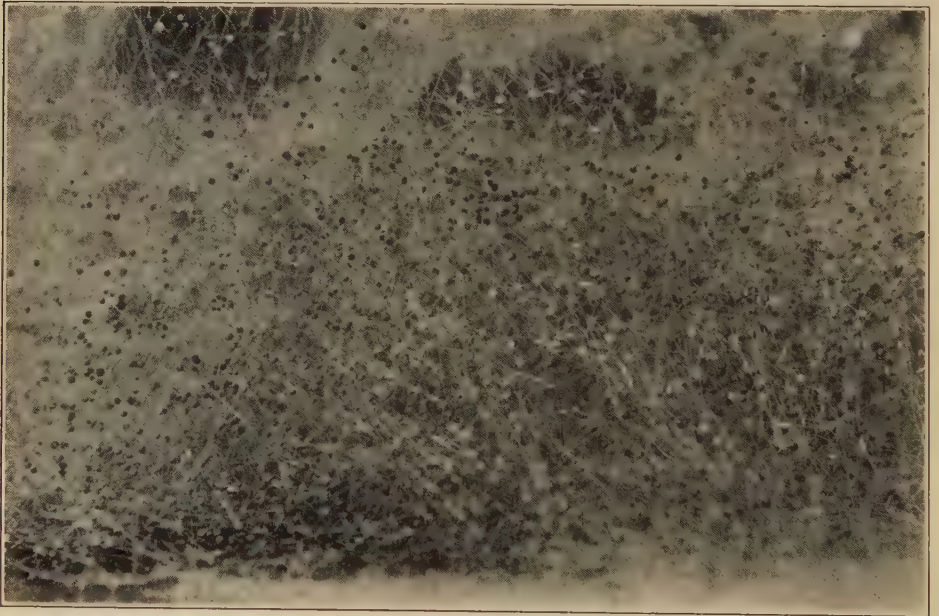


Fig. 22. A photomicrograph of the black *Mucor* mould of bread showing the fruit stalks.

will be found, and on the surfaces of ponds or on the snow, it is not uncommon to find Springtails.

- 20 Fertile queen Paper Wasps and Hornets are now hibernating. Only the winter resident and permanent resident birds are with us.
- 25 Most of the mammals have gone into their winter sleep. Frogs and turtles and snakes have long been sleeping in the mud and in their burrows.
- 30 The nature year is at its lowest ebb visibly. There is a silence and peace that will not be broken for some time.

CHAPTER V

MICRO GARDENING

ONE of the most interesting explorations that I ever made at home was in the realm of micro gardening. Anyone may possess such a garden in return for a little care and trouble. It costs next to nothing, and the seeds from which its flora grow are everywhere, free for the asking!

We require, to begin with, a few Petri dishes which have been thoroughly sterilized by steam for a few hours. This is easily accomplished by placing the clean dishes and their covers upon some support within a large covered cooking pot and allowing the steam to circulate.

While the dishes are in the sterilizer, we may proceed with the second step in making our garden, namely, the preparation of the culture medium. This material, known as nutrient bacto-gelatine, is put up in bottles and sold by dealers in laboratory supplies, and may be prepared for use by simply adding distilled water to dissolve the substance. Directions are printed upon the labels, and by this new and simple method hours of tedious laboratory work are eliminated. In the old days, it was a specialist's work to prepare a meat infusion and a sterile culture medium.

When the sterilized and covered dishes have cooled, a thin layer of the melted medium is poured into each one, the covers are replaced, and the dishes set aside until the medium hardens. They are then ready for "planting" with the seeds of the most minute species of our garden.

What we shall cultivate upon these jelly plates are colonies of bacteria, and moulds. The gardens will be exciting because, by the methods that we shall employ, we cannot be sure just what strange little forms will spring into being! But why raise germs, as bacteria are generally called? We will raise them because they are well worth learning about and because you must know that the vast majority of bacteria are harmless little plants that swarm everywhere about us.

Moulds you will be delighted with. Their beauty is often astonishing,

but with our whole micro garden we must remember that a magnifying glass or microscope will be necessary before we may fully appreciate their floral offerings.

First of all let us try an experiment to illustrate how numerous the moulds and bacteria are about our houses. Let us take one of the Petri dishes with its sterilized film of culture medium. We will place it upon the hall table and remove the cover for a few minutes. With a second dish of medium we will proceed as before, except that while the dish is being exposed, we will sweep the hall with a broom or carpet sweeper.

In two or three days after exposure, our dishes will show surprising results. The first one will be dotted with two or more yellow colonies of bacteria, consisting of thousands of offspring from the two or three air-born bacteria that were floating about when the dish was exposed. Our second dish will contain a thickly studded field of micro weeds stirred up by our sweeping operations and firmly established in the growing medium. (Figs. 18 and 19.)

There will be white patches and orange ones, easily identified as bacteria by their smooth appearance and the total absence of thread-like projections or roots. There will be moulds also, maybe in both dishes, but certainly in the second one. These are readily recognized even in early growth by the minute white or silvery hairs radiating in every direction from the central coloured mass. As they grow, the tiny uplifted spikes of flowers and fruit colour the masses. Salmon-pink, white, and greens and blues will appear and the exquisite beauty of these tiny things will be seen through the magnifier.

With other dishes of medium, exposures may be made most anywhere. A crowded theatre will yield a great crop of strange growths. An old cellar or even the open air may be worth trying. (Fig. 20.)

It is not absolutely necessary to use the prepared culture medium in growing some of the most beautiful of the moulds. A piece of bread or stale biscuit, moistened and kept under a bell-jar or inverted finger bowl upon a sheet of blotting paper, will produce remarkable results.

A lovely salmon-coloured species known as *Monilia sitophila* often appears almost at once upon moist bread, its tiny spores caught in their flight through the atmosphere. *Monilia* grows with great rapidity, com-

pletely overrunning any other species that may be present with its delicate silvery meshes. In a few hours the plant begins to fruit, deluging everything with beautiful salmon-coloured dust that tumbles in little piles about the host. This pink powder consists of a myriad spores of practically no weight individually. Small wonder that they travel everywhere through the air, ever ready to lodge and grow to lovely maturity upon any suitable host. (Fig. 21.)

Another very common mould is the black *Mucor* of bread. Its fruits are like thousands of minute black-headed pins. One can hardly avoid growing this one upon a moist bread medium. (Fig. 22.)

The green moulds are most frequently *Penicillium*, while the brown ones that grow in the prepared bacto-medium are often *Cladosporium*. Pure cultures of a single species may be made by impregnating a sterilized Petri dish by means of a needle that has been sterilized in the flame of an alcohol lamp. The needle is rubbed in the coloured mass of the mould desired, and then touched to a plate of the sterile medium in another dish and covered again at once. In a few hours the mould will be growing uncontaminated by other varieties.

Most of the moulds may be enjoyed with a simple magnifier, but the bacteria cannot, of course, be seen separately without a high-power microscope. The coloured masses upon the dishes of medium are composed of enormous numbers of individuals. Under the microscope these may appear as little rods, circular discs, or spirals. Bacteria are not animals, but plants, and these are about all that one finds, although there are a great many species. The germ of malaria is an exception, and this is a true animal form that is transmitted only by the Mosquito.

There are two other higher forms of plants that enter into our micro gardening. These are minute fungi and equally minute-leaved plants. To grow these forms, the Petri dishes are not sterilized or filled with the gelatine medium. Instead they are filled with a layer of rich rotting wood and the black soil that one finds about the stumps of dead trees in old woodlands. Just a thin layer of this stuff is required. It is kept very moist and the covers of the dishes are left in place, except when observations or additions to the collection are to be made.

One must hunt for the tiny plants that are to start these gardens in

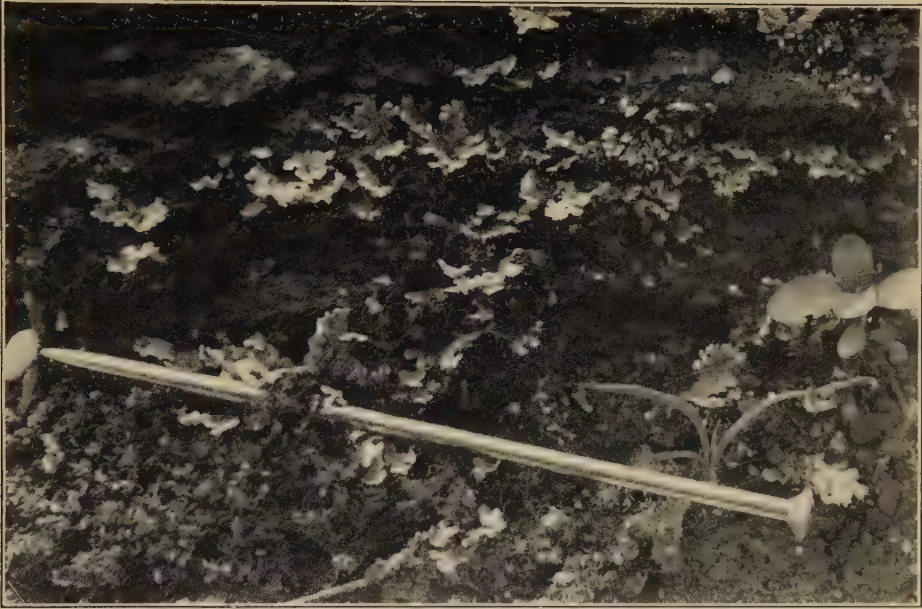


Fig. 23. Tiny true plants thrive in the micro soil-garden. It requires some patience to find the original stock, but much pleasure may be experienced in seeking it.



Fig. 24. Tiny cups and fruits and knobs, and mere pin points of pigmented things that probably botanists have never named. The ordinary pins tell the actual size of things.



Fig. 25. The One-quart World as it looked at the age of three years. It is shown about half life size. Nothing has ever been added to this aquarium except distilled water.

the same places that the medium is secured. A careful hunt will reveal numerous exquisite little organisms that may be transplanted to the garden just as they are and allowed to reproduce naturally. Some will of course die, but a little patience will reward one with a garden that will be a revelation: tiny cups of various colours, little stalks and knobs and coloured fruits. The tiniest of leaves and mere pin points of pigmented things that probably botanists have never named will be yours for the trouble. It requires sharp eyes to obtain the original stock, but once found, one forgets the time lost in the search. (Figs. 23 and 24.)

I shall say no more lest I rob you of the fun of such experiments, but a glance at the photographs that illustrate this chapter will give you some idea of the beauty of the micro garden!

CHAPTER VI

A ONE-QUART WORLD

THE 13th of February was another bitter cold day. As I looked from the window of my warm sanctum, I beheld a countryside smothered in a heavy covering of glittering snow. It was one of those rare winters that the natives called the old-fashioned kind. Heavy sleet storms, deep, hard snow that creaked loudly as the early morning wagons passed through it, atmosphere so still and crisp that the locomotives a mile away seemed to be puffing their way into my very yard, and zero temperatures that had arrived with a regularity that had become disheartening. Now, with the season well along toward March, the whole world appeared frozen and still and devoid of living things.

Throwing on my wraps and boots, I left the warmth of my study, and pushed out into the high crystal blanket. Aimlessly I wandered on for a mile or so, my footsteps unconsciously leading to a frozen pond that had always meant much to me, and which in my childhood vernacular had always been known as "Phelps'."

Phelps' stands in a tiny wood, a stagnant pondlet in summer that swarms with life. Here, seeped in the odour of mud and the wherewithal of the swamp had I obtained my supply of frogs and newts and turtles and all those exciting things aquatic, since that epochal time when I had first made the acquaintance of pockets. Phelps' early became a part of my very existence, and, as you shall see, it still exerts a peculiar fascination for me.

On this particular February day, I chopped a hole through the twelve inches of ice that covered the pond, scooped up exactly one quart of the exposed water and mud, and removed it at once to my study. Here, for two full years, that tiny portion of our world was confined, and rigidly guarded, within a square glass jar measuring 6 by 5 by $2\frac{1}{4}$ inches.

It is my purpose now to relate briefly what happened in this minute,

isolated bit of land and water during those 730 days. Throughout this entire period, I was careful to let nothing else enter the aquarium, with the exception of distilled water, which was added as the natural water evaporated between the jar and its neatly fitting cover. This was very slow indeed, so that only a very small quantity was replaced during the whole twenty-four months. By using distilled water, no foreign matter might enter from distant reservoirs, and as I was particular not to leave the little tank near an open window at any time, where wind-blown spores of living things might be drifting, all developments that I might observe would arise solely from internal factors.

Two days after gathering my material, the mud had settled, and the water had entirely cleared, revealing the primary life of my one-quart world. I was surprised to find several interesting forms already alive and kicking and as spry as though a summer sun had been bathing their watery medium in its magic rays. There were brilliant green Hydra, several good-sized Water Asels, an Ostracod, and two large leeches. In addition, I soon discovered ten Planorbis snails and twenty Pisidium "Clams," the tiniest of pearly white bivalves that climbed upon the walls of the aquarium and dropped to the bottom at the slightest vibration. There were three orders of insects represented. A single Collembolid or Springtail accomplished magnificent hops about the surface of the water. Several midge larvæ wriggled about at a deeper level, while a small spotted water beetle carrying a silvery coat of air bubbles about with him ruled supreme in his little domain.

Of plants there were few. Two remnants of Duck-weed and bits of Crystalwort and a few brown seeds floated upon the water. Inhabiting the same environment were colonies of Volvox. In the mud and sand of the bottom I found numerous kinds of diatoms and desmids, while the water itself undoubtedly swarmed with infusoria and other nameless things too small to observe conveniently without a powerful microscope.

Here indeed was a splendid beginning for an aquarium enthusiast in the dead of winter! Thinking of the few cubic inches of my one-quart world, I was staggered by the thought of the total inhabitants of Phelps' in summer.

It was not until the second week of watchful waiting, however, that the

first important development was observed within the aquarium. Then, with startling suddenness, the Ostracoda became very numerous. These little creatures are placed upon a rung of the zoological ladder of our fresh-water creatures between the Copepoda and the Malacostraca, which includes such higher crustaceans as crawfishes and shrimps. They progress by alternately opening and closing two limy shells that are hinged together like those of a clam. Seven pairs of appendages: antennæ, maxillæ, and legs protrude from the shells, and under the lower-power lenses all their intricate workings are plainly visible. (Fig. 26.)

All my Ostracoda were born of a muddy habitat and in consequence all were brown. There are many species besides these, however, and one finds them as often beautifully tinted with green and violet as sombre with the shades of their environment. In the snow pools of spring I have observed vast hordes of them. These have arisen, no doubt, from eggs of the previous year that have wintered over in a partly dried-up condition, to await the life-giving moisture of the melting snows. As all those individuals in my aquarium were very minute, I take it that these also emerged from wintering eggs, or from the other Ostracoda in the aquarium.

Strange to relate, this was the first and last brood of these creatures to appear until late in the second year, when a few more little ones made their appearance.

Plant life now began to respond to the warmth of my study, the hard brown bits of Crystalwort building out rows of brilliant chlorophyll-packed cells that gave a charming tint to the entire surface area.

In the floating seeds I found much of interest. They exhibited no signs of life at first, but gradually they began to swell noticeably, and finally each one revealed a tiny fracture in its side, into which the water seeped slowly but surely, and at length they sank to the soft muddy bottom, where new-born roots were at once sent forth into the rich food supply of decomposing plant and animal matter.

Having reached the bottom and dropped their roots, the seeds now began to ascend toward the surface once more, split and astride of the nascent plants' first leaves.

Through these simple observations, I realized, for the first time, how

much of the semi-aquatic plant life of summer comes into existence from the seeds that drop upon the surface in the fall. The sprouting of these tiny seeds was a revelation to me, for I had actually seen the coming of spring reflected in my tiny aquarium!

Late in the third week, green Hydra parents began to bud, and their numbers therefore increased greatly, indicating that the water contained plenty of the microscopical food forms upon which they subsist. Hydra are very simple and very beautiful animals consisting of an expansible emerald tube made up of cells in two layers separated by a very thin non-cellular wall, while an extremely thin skin covers the exterior. The mouth end of the tube is surrounded by tentacles, and as the animal is very elastic, it may be very long or quite short and fat. When extended, if touched, it at once contracts to a much smaller size and remains thus until the reaction caused by the disturbing factor is over. The specimens in my aquarium, *Hydra viridissima*, were green, as their name implies. Not a dull colour, but a beautiful light emerald, at once a joy to the lover of the smaller folk.

When extended, Hydra are usually securing food, which they kill by means of stinging cells. The corona of tentacles reaches out and paralyzes the food which falls into the mouth below.

This creature reproduces usually by budding, much as a plant produces a bud, but when the new individual is well formed, it separates and takes up its existence as a new Hydra, while the old one lives on uninjured. They move about considerably, seldom remaining in one position more than a few hours, and are one of the most fascinating of the smaller aquatic animals.

One of the commonest of the small but higher crustaceans in our ponds is the Water Asel, or Water Hog-louse. They somewhat resemble tiny flattened lobsters without their large claws, and one would have difficulty in overlooking them in a single scoop of mud from the bottom of any pond or brook. In the economy of nature, they are important as fish food, while they themselves are scavengers, feeding upon the decayed vegetable matter of the bottom of the pond and upon the bodies of desmids and diatoms. (Fig. 45.)

At the beginning of the fourth week a new brood of Asels appeared.

They came forth from a transparent pouch that had been carried about between the legs of the mother for some time. Within this pouch were the eggs, and when the young first burst their shells they remained within the protecting cover after the manner of young 'possums and other Marsupials. They grew very slowly after emerging from the mother, and although they became sexually mature by August and produced other broods, none ever reached the size of those originally found in the aquarium. There was plenty of food material at all times. Isolation in a small area caused the decrease in size, a phenomenon that holds true, in some cases, with higher animals.

Asels stalk their mates during the breeding season, stealthily creeping up from behind in a cat-like manner. When close to the female, there is a sudden leap and scuffle, and the female soon yields to the powerful male.

During the first week in July, a great brood of *Daphnia*, or Water Fleas, appeared in the tank. The Crystalwort had now become a solid mat of emerald upon the surface, dotted here and there with *Volvox* colonies thriving in the sunlight.

Daphnia belong to the Cladocera. They are weird little things, more or less rounded or oval with large conspicuous eyes, distinct tails, and branching antennæ, with which they propel themselves through the water at great speed. Their bodies are enclosed in shells and, being quite transparent, make splendid objects for the microscopist.

They are of tremendous economic importance to fishes, forming the chief food of many immature fresh-water species. The older individuals are also very fond of them, and it is intensely interesting to observe how this big brood appeared in my little aquarium, just at that time when the fry of our common fishes are swarming in ponds and streams. Think of the billions of *Daphnia* that are produced in a single pond at the proper time of the year for this very special purpose! The perfect order of things is indeed thrilling.

The *Volvox* colonies floating in the Crystalwort meadows of the surface increased enormously in August. They are minute oval balls of green living cells studded with brilliant dots of reflected sunlight. They belong to the flagellate protozoa. Two or three of the colonies could be placed

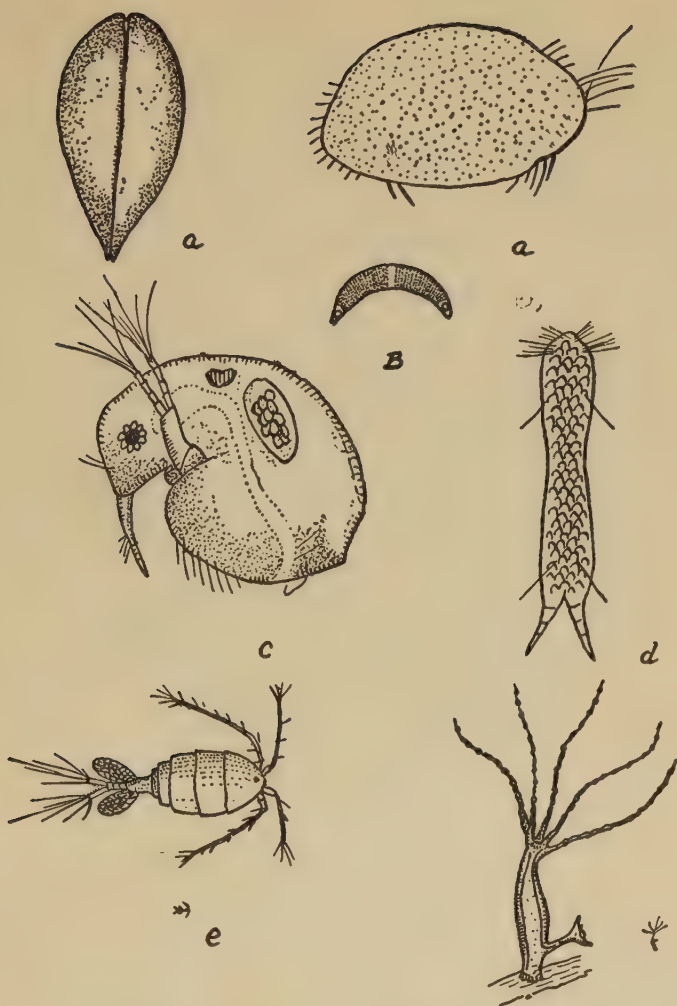


Fig. 26. Life of the One-Quart World.

(a) Ostracoda, front and side view; (b) *Closterium moniliferum* a Diatom; (c) Daphnia; (d) Gastrotricha; (e) Cyclops; (f) Hydra. All highly magnified.

upon the head of an ordinary pin. They are capable of motion and reproduce by liberating daughter colonies, which they do continually.

The next form to become a dominant one in the aquarium was the lovely crescent-shaped Diatom, *Closterium moniliferum*. It appeared and began to multiply during the second week in July, and by the first week in August millions of them must have been present. So thick were they that the bottom of the jar appeared as though painted green with

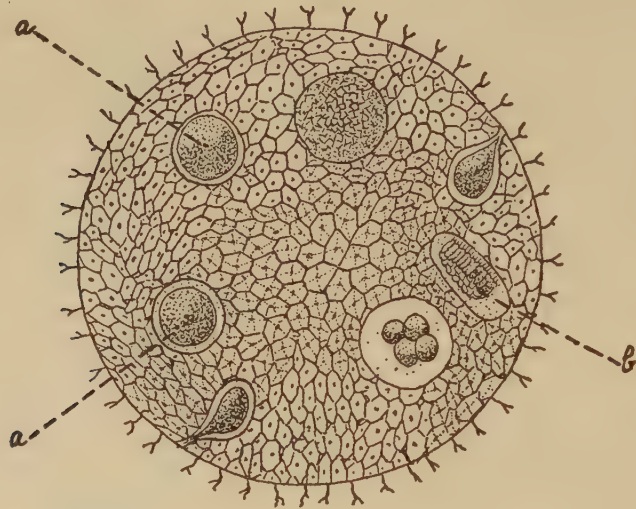


Fig. 27. Life of the One-Quart World.

A crude drawing of Volvox. Highly magnified. The egg cells are seen at (a).

a delicate emerald carpet. They multiplied until they lay upon one another a hundred deep. They climbed the sides of the aquaria in thousands, chiefly upon the glass nearest to the light, set themselves up in hundreds among the Crystalwort, and rode in dozens upon the backs of the Planorbis snails! These plants may be seen with the naked eye, but not clearly. They are green crescents containing granular material, with a colourless band through their centres. At about this season of another year, I found the stomachs of the Common Shiner crammed with this Diatom. (Fig. 26.)

This was the last important event of the first year. By December 31st, almost all of these Diatoms had died out, but it is very interesting to record that, during August of the second year, the same plant returned

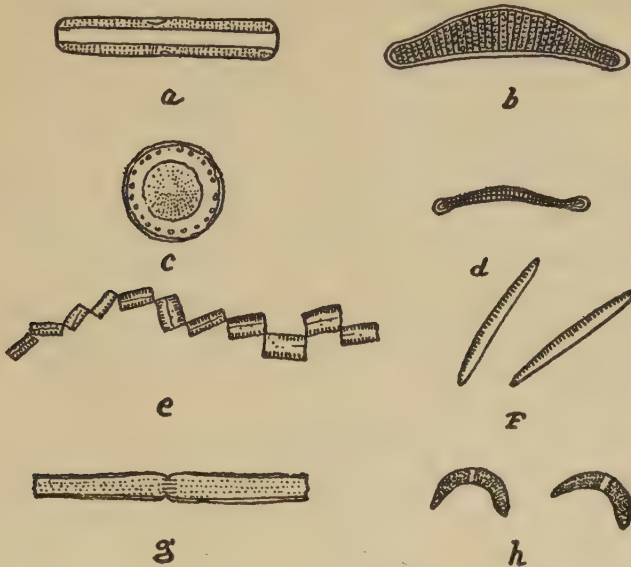


Fig. 28. Life of the One-Quart World.

Diatoms: (a) *Gomphonema acuminatum*; (b) *Epithemia turgida*; (c) *Cyclotella compta*; (d) *Ceratoneis arcus*; (e) *Diatoma elongatum*; (f) *Nitzschia linearis*; (g) *Docidium baculum*; (h) *Closterium moniliferum*. All highly magnified.

in the same fabulous numbers, ran its course, and died out again, just as it undoubtedly does under natural conditions.

The forms which now survived, that is, at the beginning of the second year, were as follows. These are placed in the order of their numerical strength:

1. Volvox.
2. Hydra.
3. Water Asel.
4. Planorbis snail.
5. Ostracoda.
6. Pisidium.

The only surviving plants were Crystalwort, some unidentified Algæ, and numerous forms of Diatoms.

Nothing happened of note during the entire second summer, except the appearance of the green Diatom mentioned above. The Hydra now gradually died down and disappeared altogether. Likewise the Planorbis snails grew fewer and fewer and one could count the empty shells of all that had ever lived in the tank, ranged like sad little tombstones about the upper edges of their world.

Once again there was much activity among the dwarfed Water Asels, but a day later, as though unable to withstand the excitement of renewed sexual activities, the males died and were promptly and unceremoniously devoured by their heartless mates.

Everything began to look old and tired, and save for the microscopic "Sea Lions" that I managed to discover, browsing and progressing by trial and error among some filaments of Algæ—Gastrotricha, they are called in zoology—I looked upon my little world with sadness, for it appeared to be truly upon the decline. (Fig. 26.)

Then, one day, as I was making a few last observations upon the quarter inch of new mud that had formed from the disintegration of things during the many months of my vigil, a strange form flashed past my lens. Looking up excitedly, I found a Cyclops with bulging egg sacs clinging to the glass. Soon I found a second, and a third, and within two days a dozen darted about the aquarium! I was elated and no less astounded. How could such an occurrence be explained?

It was early February. This unexpected development meant that within a very short time, just as my little culture was about to become two years of age, a new form of life that had arisen from the ashes of all those that had succumbed would be swarming within it! In addition to this wonder, in examining the alimentary tract of the last Water Asel to die I had found the ciliated discs of a Protozoan quite unknown to me.

With these startling closing events of the two-year period of observation, I am answering once and for all, with my little one-quart world, the question, "What is there left to study at home?"

CHAPTER VII

THE EARTHWORMS

Lumbricus terrestris and *L. fætidus*

WHEN I was a small boy, I remember distinctly my frequent excursions in search of "Night-walkers," as I called those extra-large Earthworms that made up the bulk of my fish bait. I went with a lantern, searching along the lanes and walls, where leaves had been allowed to collect and lie rotting since the previous autumn. On warm spring nights there would be numbers of them with their heads protruding from their burrows, among the leaves and grass, and if a shower were in progress or about over, the ground would be alive with them.

As I walked slowly along with my lantern held close to the ground, the worms would draw rapidly back into their holes and one would have to be very quick to catch them. If they were unusually numerous, as sometimes happens, a distinct rustling noise would be heard as my collecting trip progressed.

In a short time the bait box would be full, and as far as Earthworms were concerned, that would be the end of the matter until the fishing spirit moved me again. Since then I have learned to respect the lowly Earthworm and have found a great deal of interest in its life and habits. The worm, though seldom credited properly, holds one of the most important economic positions of all. Without the worms, the land would be more arid. Vegetation would not reach its present state of luxuriance, and indeed much of the earth's soil would lie foul and useless to many plants.

There is so much to tell about worms that it is going to be difficult to choose the most important points, and still harder to squeeze them into this chapter.

In the first place, worms are most numerous at the surface of the

ground at night, during or just after a shower. They come up to the surface to feed, as they are truly nocturnal animals, but the reason for their abundance when it rains is perhaps best explained by saying that by a wise provision nature drills the ground with holes, into which this water may run and the all-important oxygen of the atmosphere may penetrate.

Few of us think of worms as leaf- and grass-eaters, but they do actually consume large quantities of vegetable matter—not living leaves and grass, but the dead and dying vegetable matter that lies upon the ground. Holding fast in their burrows by the tail-end, the worms reach out in all directions, stretching themselves to great lengths and grasping bits of food, which they pull below the surface. Here, part of the material is eaten, while vast quantities of it pass into vegetable mould that helps to make other plants grow. Worms have no eyes or ears, yet they are very sensitive to light, for they dart into their burrows with great rapidity as the lantern approaches.

In addition to the vegetable matter which worms eat, great quantities of soil also pass through this vast army. From this soil they assimilate what is useful to them, leaving the remainder each night upon the surface in the lobed and familiar castings that everyone has seen. Stop for a minute to consider the countless individual worms that inhabit every acre of ground. Think then of the weight and depth of a single year's castings that are left upon the surface and you will begin to realize that the worms are actually responsible for the ploughing and turning over of the earth as the years go by. (Fig. 29.)

When Darwin was a student at Edinburgh, he began to study the activities of the Earthworm. He measured the ground in various places, and estimated the approximate number of worm castings found in these restricted areas. He made repeated estimates of all kinds and patiently and insistently studied these creatures. Then, the year before he died, appeared his famous book, *The Formation of Vegetable Mould through the Agency of Earthworms*. In this volume he mentions the fact that, in British soil, there are found on an average 53,000 worms to the acre. Some ten tons of earth pass through these in a year. As they have been doing this for countless years, it is easy to realize the changes that worms gradually bring about. Darwin found that their castings cover the sur-



Fig. 29. An Earthworm and its recent casting—a familiar sight to all of us.



Fig. 30. An Earthworm, much enlarged, showing the swollen clitellum, or egg capsule. This is discarded over the worm's head. Within it the young worms develop.

face to a depth of three inches every fifteen years. Thus in the burial of ruins, worms have often played an important part.

In biology, the Earthworm is a very important animal. It is usually chosen as the representative of the animal kingdom for study and comparison, because of the simplicity of its structure, the clarity of its position in relation to other animals above and below it in the scale of organization, and the ease with which it may be obtained and dissected.

There are many species of worms in the world, but the commonest one of the lawn and garden is called *Lumbricus terrestris*, and may be identified by its stout body and flattened posterior region. Another very common variety is *Lumbricus fœtidus*. It is smaller and red, with a disagreeable odour, and is found in heaps of rotting vegetable matter.

The pointed end of a worm is the mouth end, and the flattened end the "tail." In moving about, the pointed end usually progresses forward. In biology this is of vast importance, for the differentiation between the two ends of the worm is but the beginning of a series of modifications, extending upward through more and more complex stages until man himself is reached.

Other features of importance in the Earthworm, which become much clearer in individuals as we ascend the ladder to higher forms are: (1) The fact that one particular side is habitually turned upward and becomes the back, while another and lighter-coloured side is habitually turned down and might be termed the belly. (2) That if we were to place a worm upon its belly and cut it longitudinally, from end to end, and exactly in the centre, both resulting halves would be exactly similar. This is known as bilateral symmetry and as we ascend, becomes most striking in the human body. From the two facts outlined above, we see that the worm reveals two fundamental laws of organization: the Law of Difference or Differentiation, and the Law of Likeness or Symmetry.

Another important feature, in view of conditions existing in higher animals, is the fact that the body is marked off by grooves into a series of similar rings or parts called somites. These grooves that we see on the exterior represent real divisions within the worm, which affect all the organs of its body and which may be traced, though often with difficulty, in the divisions in the bodies of higher animals.

I must dwell no longer on the anatomical side of the worm, but before closing the chapter I must speak briefly of reproduction, a process of peculiar interest in these creatures. To a certain extent worms can regenerate themselves, for if one be cut in two, the anterior section will often regenerate the portion that is missing, while the posterior section may generate the anterior portion!

Worms are hermaphrodite. That is to say, every individual is both male and female. Despite this, it is necessary for the individuals to pair, and this takes place at night during the spring. It will be noticed that on a mature worm some of the somites or divisions somewhere between the twenty-eighth and thirty-fifth are swollen, forming a distinct cylindrical girdle called the clitellum. (Fig. 30.) When the worm is ready to lay its eggs, the glands within the clitellum pour out a tacky fluid, which hardens and forms an even more distinct girdle around the body.

This girdle is now worked forward over the head and discarded. It contains the fertilized eggs, and as it leaves the parent, its ends close tightly, forming a capsule that is more or less pointed or sometimes rounded at both ends. These capsules may be found under stones or in earth and manure heaps in May and June and are often hard and brown.

In the deep forest of the Island of Dominica, I found worm capsules that were perfectly round and whitish and partly transparent. These were buried in rich jungle soil and a single worm hatched from each.

Within the capsules of our native species there are more than one individual. When they burst from their capsules to take up their lives in the earth, they measure about an inch in length, and as they have no clitellum at this time, immature specimens may be told at a glance.

Finally, let me emphasize the importance of studying the biology of the Earthworm, for when one has learned its habits, the functions and workings of its body and organs, the student has for all time in his mind many of the fundamental principles of the biology of higher animals.

CHAPTER VIII

A FEW INVERTEBRATES OF THE SEA

IT WOULD be well for the gatherer of seaweeds to look carefully at his specimens, for it is one of the commonest mistakes of the nature-lover to confuse the true vegetable seaweeds with those often very similar Hydroids which are interesting members of the animal world.

Hydroids are colonies of animals that are associated and live a communal life. If we examine our "seaweeds" with a powerful hand glass, we shall occasionally be surprised to find the stem of one of these "plants" indented with small cups from which tiny tentacles may be seen protruding. It will be noted also that the tubes, which form what might correspond to the stems of the plant, are composed of a horny substance through which a thread of life connects the whole colony of zooids. Like the Siamese twins, they are one, yet each member of the colony may perform separate duties.

Some of these, the ones with tentacles, obtain the food for the rest as well as themselves, while others reproduce the young, and here we come to one of the most remarkable and little known of the common things in nature.

Young Hydroids are developed and released by the reproductive zooids as tiny Jellyfish or Medusæ, as they are scientifically called. They are developed as little piles of saucer-shaped objects attached to one another at their centres. When released, the animal is at the highest point of its development.

Now, when the little Jellyfish itself makes ready to reproduce its kind, it deposits eggs, which are called planulæ. These are able to swim about by themselves until they find a suitable object to which they may attach themselves, and here they grow into the plant-like Hydroid colonies once more. We see, then, this intensely interesting cycle, which is like a plant at one stage and a Jellyfish at the other.

The Hydroid cycle is not always like that described, for there are species that reproduce by budding. Some have no plant-like stage at all, while still others produce no Medusæ.

Biologically the Hydroids are very important, as they illustrate very beautifully the alternation of generation, and also such interesting things as true communal life.

One of the animals that develop directly into the Jellyfish, without the



Fig. 31. Marine Invertebrates.

(a) *Trachynema digitale* (reduced); (b) *Aurelia flavidula* (much reduced); (c) Strobilia or saucer stage of *Aurelia* (much enlarged); (e) A Ctenophore or comb-jelly (one-half life size); (f) A young Starfish (natural size); (g) Pluteus stage of a Sea-urchin (greatly enlarged).

plant-like stage, is known as *Trachynema digitale*. It is a small rose-coloured bell of jelly, studded with four red eyes. Through the jelly may be seen the tentacles below and the eight curious sacs which contain the eggs. (Fig. 31.)

Other Hydrozoa produce a calcareous substance which grows into strange forms as the colony increases. The Elkhorn Coral so common in the South is a product of these tiny animal colonies, although it is not a

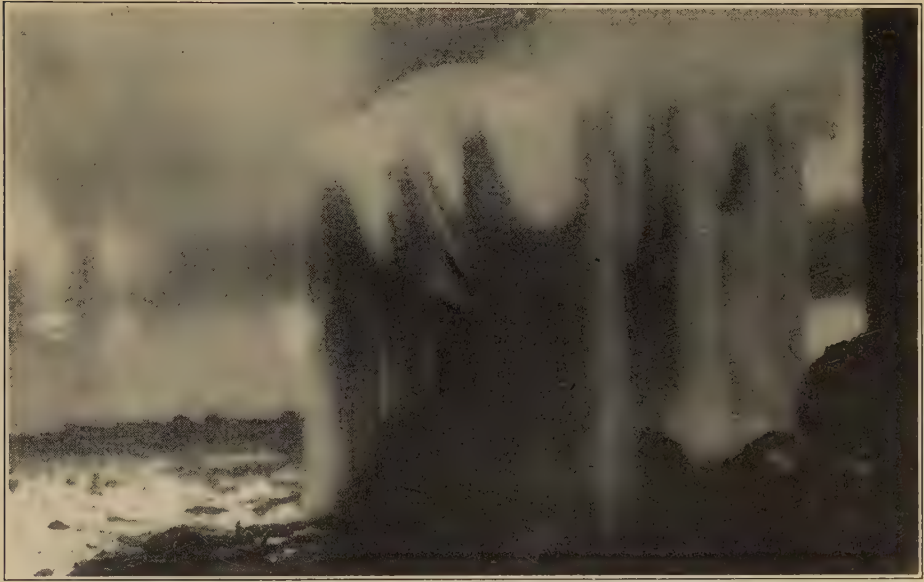


Fig. 32. The Sun-jelly, *Cyanea arctica*, photographed in an aquarium. One third natural size.



33. *Asterias forbesii*, a common Starfish. One third natural size.



Fig. 34. The Cake Urchin, *Mellita testudinata*. One half life size.

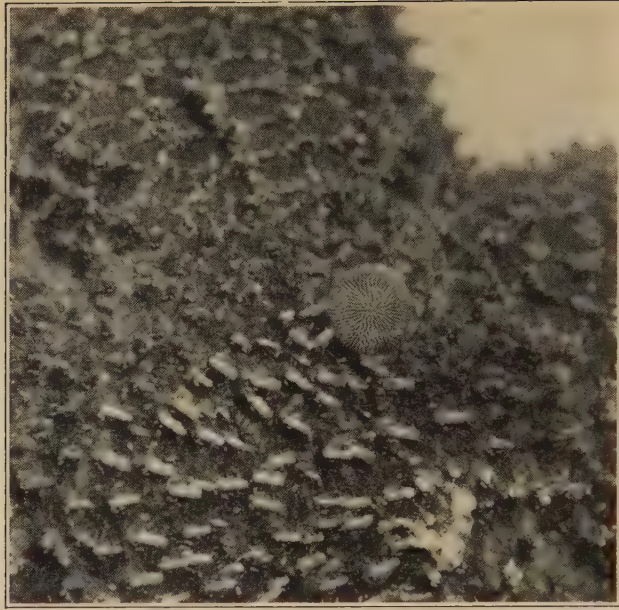


Fig. 35. Surface of the Starfish *Asterias forbesii*, at the angle of two arms, showing the madreporic plate, much enlarged. This plate is probably the intake of the water vascular system.

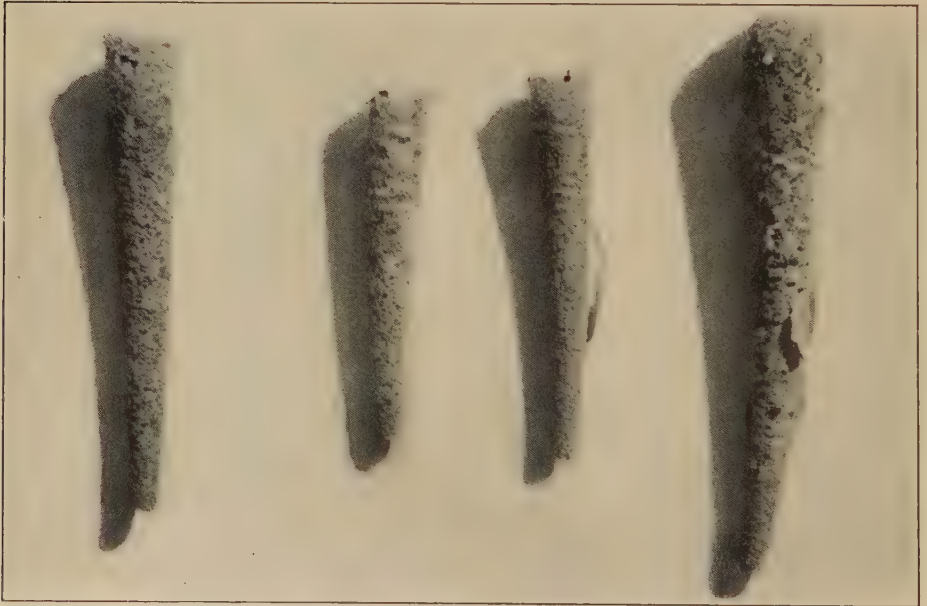


Fig. 36. Tube houses made of sand grains by the common Marine Worm, *Cistenides gouldii*. They are often found in large numbers after the tide recedes.

true coral, for these are made by similar animals, each of which is complete in itself.

One of the commonest Jellyfish is *Aurelia flavidula* (Fig. 31, b and c.). It is found in Long Island Sound as early as the middle of April, but does not mature until June and July. This species is a disk of bluish-white jelly with very short tentacles surrounding it. In its outline eight notches will be seen, each containing a spot, and these are supposed to be eyes. In the centre are four sacs which contain the eggs. Another common species is the large red Jellyfish with long tentacles and a white scalloped disc. This is the Sun-jelly, *Cyanea arctica*. It is common along the shore in early September.

The eggs are liberated in July and August, after which the parents soon lose their strength and die. Hundreds of them will often be found upon the beach, where they have been left to die, after a storm, and even in fair weather. They appear to be of no further use in the world once the eggs have been set free. (Fig. 32.)

Closely resembling the Jellyfishes in consistency are the Comb-jellies or Ctenophors. These progress by means of cilia or "hairs," which are arranged in eight rows around the body. These cilia are in reality little propelling oars or paddles, which move rapidly with a waving motion, and the animal progresses through the water without alternately contracting and expanding, like the other Jellyfishes. At night the Ctenophors are phosphorescent, and in the daylight one sees opalescent bands of light as the cilia wave and thus move the creature about. The commonest species that we have swarms in Long Island Sound and its inlets in summer. It is three or more inches in length and an inch and a half in width, somewhat resembling a bell jar. In colour it is pinkish and has no tentacles like the other Jellyfishes. This is *Idya roseola*. (Fig. 31.)

The stings received from the larger Jellyfishes, with which every bather is familiar, come from the minutest of stinging cells situated in the tentacles of the animal.

Under the microscope they appear like tiny sacs, in which are still more minute stinging springs, which in turn are poisoned with a substance that causes a pain similar to that which one feels when a nettle has been brushed against. When the tentacle comes in contact with an object,

these tiny springs are released, carrying with them the poison that causes the irritation. Stinging is the natural method of the animal in killing or numbing its prey.

In that area between tide marks, which abounds with so many things of interest, we find the familiar "Clam Worms" which are often used as bait. They belong to the genus *Nereidæ* and are true worms. The importance of other worms has been discussed in another chapter, but I am so frequently asked about these marine representatives that I must say a few words here in regard to them.

They live in burrows and among the stones and other cover of their habitat. At night they sally forth from their hiding places to become free-swimming, ferocious creatures, that attack other worms and small organisms of various kinds. It will repay the investigator to place a number of them in an aquarium filled with salt water, sea lettuce, and plenty of sand. In this they will make their burrows, and at night they may be observed swimming about in search of their prey.

There are many species of worms that live in the salt water, but this common reddish iridescent species is *Nereis pelagica*.

A very common species that often comes to the notice of bathers is *Cistenides gouldii*. It is two inches in length, with a red body marked with blue, and bears two groups of beautiful gold bristles at its head end. In the sand they construct wonderful conical tubes of sand grains which are often found by the hundred after the tide recedes. Here is one of the most beautiful objects in nature. Under the lens this house of masonry will be seen to be constructed of a single layer of building material so perfectly joined together and so smooth as to appear as if planed and finished by some ingenious machine of man's. (Fig. 36.)

Two Starfishes abound in the waters included in the territory of this book. Both are five-armed, rather heavily built, and covered with short thick spines. They look very much alike but may be told apart by the colour of the madreporic plate, which is a round hard spot situated at the angle of two of the arms. In *Asterias vulgaris*, it is of the same colour as the rest of the animal, which may be brown or purple, or even red. In the other common variety, *Asterias forbesii* (Fig. 33), this plate is always a very brilliant orange.

These two Starfishes feed upon mollusks, and the latter species is very destructive to the oyster beds. In an aquarium they will live very well, and it is interesting to watch the slow but certain methods by which an oyster or other mollusk is finally forced to open to the devourer. Starfishes may be cut in two or three pieces and go on living as though nothing had happened. They seem to possess endless vitality. They cannot live out of water, however, for any length of time, and living specimens must be looked for just beyond the low tide mark or in deeper water. Most young Starfishes are free-swimming individuals, although in some species the babies are retained in the mouth of the mother for some time before being liberated.

Occasionally, on our beaches, but most often upon those that face the ocean, we find curious flat discs, white, bluish-white, or purplish. They bear interesting patterns upon both surfaces, and there is a small round hole or mouth upon the lower surface. These are commonly called Sand-dollars, or, more correctly, the Cake Urchins. The pattern upon the upper side, which consists of delicately etched lines, is in the form of a star, and in some of them, a very perfectly formed five-pointed star is surrounded by the five petal-like figures that form the larger one.

The commonest species is *Echinarachnius parma*. When living, this form is covered with tiny spines which impart a purplish colour to the animal. It forms an important article of food for cod and haddock and sometimes occurs in great numbers upon the sandy bottom. When the spines have been removed by the action of the sand and waves, the surface of the shell is reticulated with finely indented lines.

In *Mellita testudinata*, another species, the shell is punctured with five long narrow slits known as lunules. (Fig. 34.) This is the greenish or bluish variety less often seen than the one mentioned above.

These animals reproduce by means of eggs, which are discharged into the water. The young, or larvæ, are quite unlike the parents and are called Pluteus. This stage is free-swimming and undergoes some other remarkable changes before it becomes a mature Cake Urchin. (Fig. 34.)

CHAPTER IX

BARNACLES, SHRIMPS, AND CRABS

ALTHOUGH the heading of this chapter mentions only three kinds of individuals, there are really a great many other creatures such as the Lobsters, the Beach Fleas, Wood-lice or Pill-bugs, and numerous others that are included, with those in the title, in the great class Crustacea. We cannot, of course, treat them all in this volume, but I have included original studies of some of the more important species, and in most cases these studies relate to those most often met with by the nature student.

The Barnacles, or Cirripedia, are intensely interesting crustaceans. We all know a barnacle when we see it, yet how few have ever made the simple observation of watching the animal at its labour of food gathering! If a stone or a bit of wood that is well encrusted with barnacles is placed in a jar of salt water, the animals will extend themselves almost immediately.

At first the neatly hinged doors of the shell will open and in another second or two the long feathery appendages of the barnacle will reach out into the water and commence a fanning motion that not only stirs up that minute manna which constitutes the animal's food, but also carries it mouthward. Touch the barnacle ever so slightly, or withdraw its support from the water, and instantly the arms are withdrawn and the shelly doors closed against the danger. When the tide goes out, the barnacle digests its food and then fasts until the welcome return of the water brings it its next meal.

The young barnacle is called a Nauplius (Fig. 37) and looks nothing like the mature form. It is a tiny one-eyed, free-swimming animal with a delicate shell and three pairs of legs. After a while, an astounding transformation takes place, for it moults and becomes its own double, appearing with two shells, two eyes, and six pairs of legs! It now attaches itself to some

support and looses its mollusk-like shell. The cement that holds the animal in place is of its own manufacture and is very strong. Once in place, it never leaves it again, and soon develops its typical barnacle shell and its feathery organs for obtaining its food. In a single season a barnacle grows from a minute, newly fastened animal to the large tough shell with which we all have come in contact. (Fig. 38.)

The Ship Barnacles or Goose Barnacles possess a long stalk or "neck,"

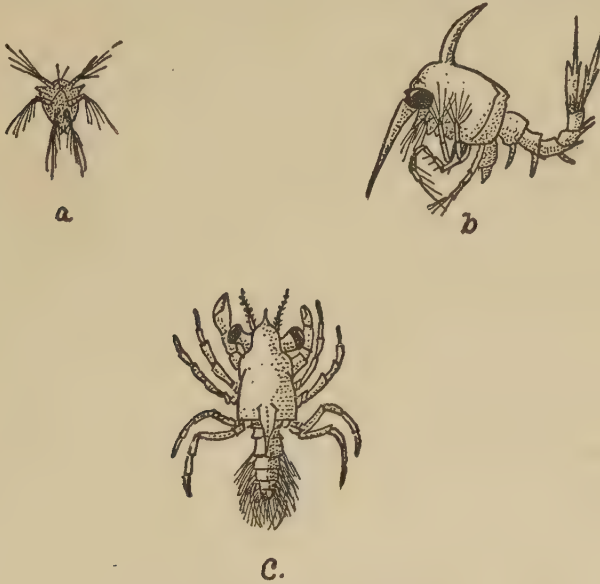


Fig. 37. Early stages of barnacles and crabs.

(a) Nauplius; (b) Zoëa; (c) Megalops. All very much enlarged.

but our common forms belong to the genus *Balanus*, and are more or less conical shells. *Balanus balanoides* (Stimp.) is the Rock Barnacle that occurs in vast numbers in the Atlantic coast region. The other common barnacle, *Balanus eburneus*, known as the Ivory Barnacle, has a smooth shell, and is lower in form than *Balanoides*, and the edges of two of the valves of the opening are serrated. There are other forms in addition to these, but they are less often met with by the average observer.

Every inlet along the Sound in the territory covered by this book supports large numbers of an interesting small crustacean called the Sand

Shrimp, *Crangon vulgaris* (Fig. 39). It is two or three inches in length and varies in colour according to its habitat. When found on the bottom of a muddy brackish inlet, it will be much the same colour as the mud, whereas the specimens collected from the sandy bottom along the shore will resemble the sand very closely indeed.

This shrimp is usually too small to eat, but makes excellent bait for smelt and may be easily caught by pulling a fine mesh net through the sea lettuce and algæ that grows so thickly about the shores of the inlets.

The Sand Shrimps make excellent subjects for study in the aquarium and will live and thrive upon tiny bits of meat or dried shrimp fish food. They are very active and always hungry, and sail about the waters of the aquarium like many tiny aëroplanes.

In the spring the females extrude their eggs, which are carried about for a considerable period before the young are finally liberated from them. The edible shrimp is a much larger species, and most of these shrimps are gathered for the markets south of the territory included in this volume. One of the larger edible species is *Penæus brasiliensis*, however, which ranges as far north as Long Island.

The most valuable of all the crustaceans is, of course, the Lobster, *Homarus americanus*. It has a wide range, being caught all the way from the cold waters of Labrador to the warmer shores of New Jersey, and is caught in hundreds of thousands each year.

The animal needs no description, but it will be of interest to many to know of the early stages of this species, which are very interesting.

The eggs are carried about by the female on her legs, where they appear to be fastened by some strange glue or cement secreted by the Lobster. The young are called Zoëæ and do not resemble the parents very closely. They cling to the mother for a time before going out into the world for themselves.

During the first three years of its life, the Lobster moults its shell completely sixteen times! After this the female moults once a year and the male twice, a difference which would be difficult to explain.

The food of the Lobster is entirely decaying animal matter. They are true scavengers of the sea, yet, as we all know, their flesh is one of the most delicately flavoured of all marine foods.

We now come to the Hermit Crabs which are so common along our shores.

These are the little fellows that scurry over the sandy bottom bearing the old shell of some mollusk or "snail" upon their backs. Many of us do not stop to think that here is a specially modified crab of minute dimensions using a shell for its house. Our first thought is of the animal as a whole, and we pass it by as a strange little creature with claws like a crab, but possessed of a shell of its own like that of a snail.

It will repay the investigator for his trouble if he will secure some Hermit Crabs along the shore at high tide and place them in an aquarium for study. If one of these is gently pulled from the shell, it will be seen that its body has been modified to fit the shell of its choice. Thus a spiral shell will contain a hermit with a spiral body and a plain shell will contain one with a plain body.

On this soft unprotected portion of the animal, its modified and tiny posterior legs will also be seen, the last pair being little more than a pair of hooks for holding on to the shell in which the crab lives.

It is very amusing to pull several of the crabs from their shells without injuring them and then allow them their freedom in an aquarium in which an insufficient number of empty shells have been placed. The battle royal which ensues is extremely serious and energetic. No form of marine life is any better suited to illustrate special adaptations than the Hermit Crabs, and they will repay the investigator who is careful and observant.

On many of the shells will be found a soft, pink, spongy substance. When the shell so covered is placed in salt water, this will be seen to be a colony of Hydroids (Hydractinia) which will expand their tentacles and afford a very easy method of studying these interesting creatures.

Our commonest Hermit is *Pagurus longicarpus*. It inhabits the smaller shells, lives in shallow water, and possesses a metallic sheen which separates it easily from the larger, light red *P. pollicaris*.

Where the shell is found to be coated with Hydroids, or other life forms, such as tiny anemones, a mutually beneficial partnership has been formed. The Crab may keep the colony of polyps in the neighbourhood of

food, while the latter protect the Crab from its enemies. This is called symbiosis.

The female Hermit Crab carries the eggs about with her for a time, after which the young are released and set themselves up in shells of their own.

Of the larger true crabs we have numerous species, the commonest of which are the edible Blue Crab, *Callinectes sapidus*, which is common in the inlets in summer; the Lady Crab, *Ovalipes ocellatus*, of sandy shores, which is white or very pale yellow, and covered with rings of red, and purple spots; the Jonah Crab, *Cancer borealis*, a big fellow which is red on the upper surface and yellow underneath and is an edible species; the Green Crab, *Carcinides maenas* (Leach), which is green, mottled with yellow, and lives in pools formed between tide marks by the receding water, and the two Spider Crabs, *Libinia dubia* and *L. emarginata*, which are found in muddy places about the shores, and in the seaweeds which lie between tide marks. The Spider Crabs are easily distinguished by their brown rough bodies, the beak-like projection at the front of the shell, and the warts, hairs, moss, and seaweed which grow upon their backs.

There is also the very minute Oyster Crab, the female of which lives within the Oyster's gill. This is *Pinnotheres ostreum*, but is not often found except by chance.

The Fiddler Crabs of the genus *Uca* are very abundant.

The species *Uca minax* is a very common sight on the salt marshes and along the edges of the inlets, where it lives in burrows that are arched over with mud. At almost any hour of the day, but particularly toward evening, the Fiddlers may be seen in their doorways squatting comically upon their "stomachs." Above them, like drawn swords, they hold their greatly enlarged right or left claw which they wave to and fro periodically in the grotesque and stiff manner of Punch and Judy dolls. (Fig. 43.)

At the slightest sign of danger, they retreat within their burrows. On the big marshes, where people seldom go, they occur in August in such huge numbers as to produce a distinct and uncanny noise. I have found that the males greatly outnumber the females. The former may be told by their single, greatly enlarged claw, which may be either the right or left one.

During the third week in June, enormous numbers of minute but per-



Fig. 38. *Balanus balanoides*, the common Barnacle, with its food-catching apparatus extended. Much enlarged. Barnacles begin to feed thus, as soon as the tide covers them.



Fig. 39. The common Sand Shrimp, *Crangon vulgaris*. Life size. These creatures are beautifully protected, their colouring varying according to the habitat.

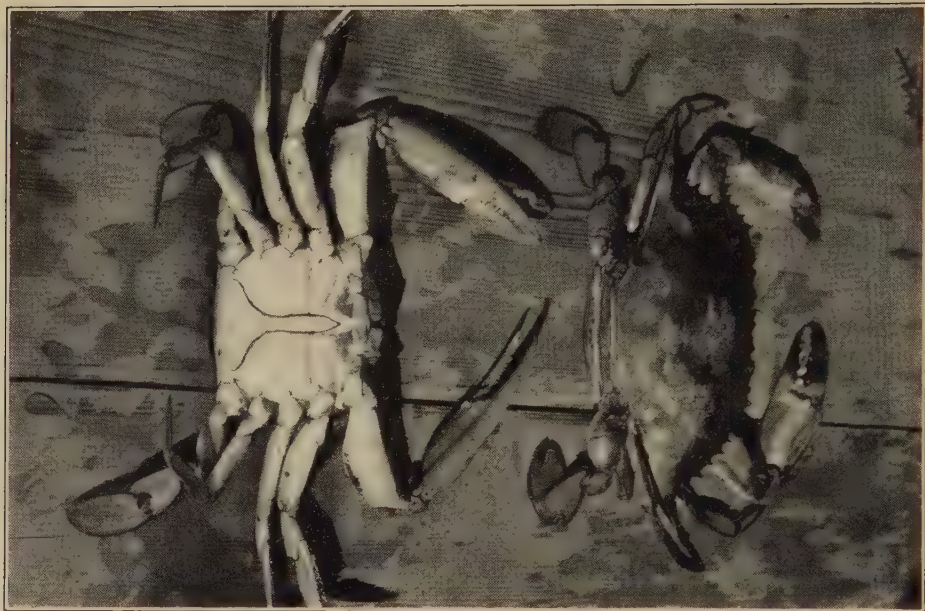


Fig. 40. The Blue or Edible Crab, *Callinectes sapidus*. One quarter life size. These are a male and a female. At certain times this species moults and it is then known as the Soft-shell Crab.



Fig. 41. An enlarged photograph of a common small Mud Crab. It lives in the muddy inlets under stones. Twice life size. Note the enlarged right claw.



Fig. 42. At the left, the Beach Flea, *Orchestia agilis*, and at the right a Sow Bug (Oniscidæ), both common crustaceans.



Fig. 43. The Fiddler Crab, *Uca minax*. In the lower centre of the picture, four minute youngsters may be seen. One half life size.



Fig. 44. An enlarged view of the two surfaces of the Sow Bug (Oniscidae). These "bugs" are a favourite food of toads.



Fig. 45. The Water Asel, *Asellus communis* Say. Although a poor illustration, it will serve to give a good idea of the creature's general appearance. Twice life size.



Fig. 46. Young Oniscids or Sow Bugs feeding on rotten wood. A pin has been included in the photograph to show their size.

fect crabs may be found in the same habitat as their elders occupy. Their tiny burrows are in strange contrast to the yawning ones of the mature crabs. Some of these youngsters measure but four millimetres in width, yet at this early time they bear the same single swollen claw on one side.

The young feed entirely upon vegetable matter, their stomachs containing fragmentary chains of green Algæ and dead matter intermixed with some mineral matter also. In one I found a parasitic worm known as a nematode, but this was dead and may have been eaten this way, or taken into the stomach with vegetable matter. Mature crabs subsist upon the same diet, together with a wide variety of dead vegetable matter.

Uca pugilator, another species of Fiddler Crab, inhabits beaches where the sand is hard and where food is easily obtained, while a third one, *Uca pugnax*, is associated with the first one described, but does not appear to construct the arch over its burrow.

Many crabs pass through strange stages in early life that in no way resemble the parents. These stages are called the Nauplius, the Zoëa, and the Megalops. On the other hand, some species are born as perfect but minute adults. (Fig. 37.)

We all know the Sand-hopper or Beach Flea, *Orchestia agilis*. This is a crustacean also and must be included here, as well as the common Pill-bug or Sow Bug, a land form that is found under stones or wood or damp rubbish of almost any kind. (Figs. 42, 44, and 46.)

The Pill-bug is an Isopod and carries its young about for a time in a pouch between its legs.

Another Isopod, and one that lives in fresh water, is the Water Asel, *Asellus communis* Say. (Fig. 45.) This very abundant species swarms in stagnant ponds and in running brooks of small size. Its favourite habitat is in partly or wholly stagnant water filled with the gaseous muck of decaying vegetation. In such places, one cannot scoop out a cupful of bottom material without bringing some of these little creatures to the surface.

The Asellids belong to the higher Crustacea. One finds little or nothing concerning the life history, so I write these few notes with special pleasure. The Water Asel is only another of those extremely common

creatures that have been neglected almost altogether in the past. The males are considerably larger than their mates and are ardent wooers, stalking their females stealthily like a cat. This stalking is followed by a sudden leap, during which the female is securely caught and held during the mating which ensues.

Breeding goes on the year round, as it is not uncommon to find females with egg masses in January and February after cutting a hole in the ice to obtain them. The eggs are carried in a pouch or bag, which is quite transparent and is situated up between the legs of the female, resembling a large blister protruding beneath her. The young hatch out within this pouch and are carried thus for some time before being liberated.

A brood so liberated in an aquarium on February 17th were white and much like the parents except for the four posterior pairs of appendages, which were much branched with very delicate spine-like processes. In addition to this difference, they possessed one less segment than the adults.

They began to feed at once, but their growth was quite slow; but this may possibly have been due to their artificial surroundings. Some of the young would ride upon the mother's back, while others preferred the shell of a snail, using this as a lift by which to reach the plants at the top of the aquarium.

On May 15th, these young measured five millimetres in length; on July 1st, seven millimetres; and on August 1st, ten millimetres. They were then old enough to produce broods of their own.

Both the young and old feed almost exclusively on those microscopical plants known as Diatoms. They also take a small amount of mineral matter into their bodies, possibly as grinding material.

Diatoms, which make up the Water Asel's food, are microscopic one-celled plants inclosed in membranes of saliceous material. They are very numerous in most waters. The following Diatoms were identified from the alimentary canals of a number of Asels: *Gomphonema acuminatum*, *Cyclotella compta*, *Diatoma elongatum*, *Epithemia turgida*, *Ceratoneis arcus*, *Nitzschia linearis*, and *Docidium baculum*. In addition to these there were six other unidentified species. (For illustrations of these Diatoms see Fig. 28, Chapter VI).

One of the strangest of living creatures to-day is the Horseshoe or King Crab. I have placed it in this chapter because I believe that the average reader would naturally search for information regarding it in that section of the book which deals with the true crabs.

The Horseshoe Crab, *Limulus polyphemus*, is a very difficult invertebrate to classify, for being of very ancient lineage, it appears to be the only survivor of an otherwise extinct race. There is one other species inhabiting the coast of Asia, but aside from these two, the nearest relatives of this creature are fossils of great age. Among living things, it is probably closest to the spiders and scorpions, although it also possesses some crustacean characteristics.

In summer, the Horseshoes come up on the shores, sometimes in great numbers. They are fed to poultry and hogs and sometimes used as manure. If the crabs are caught alive and penned up for some time beyond the reach of food and their meat afterward carefully boiled and cleaned, they are indeed good eating. I suspect that many brands of cheap canned crab meat is nothing more nor less than old King Crab camouflaged beneath a fancy label.

From the middle of June well into July males and females may be seen mated. The males may be told by their inferior size, and the best place to look for the pairs is along the grass-grown borders of shallow muddy inlets in the early morning and at evening. Here they come to breed, and occasionally a female will be observed with two males as escorts, each clinging to the other in a line like circus elephants hanging on to each other's tails.

The female makes a hole in the mud just at high-water mark and deposits hundreds of pale yellowish-white eggs in it, afterward covering them up with an inch of mud or refuse. Before they are covered, however, the male ejects his milt over them, and thus they are fertilized.

The eggs measure three millimetres in diameter. Some are deposited in June, but July 1st is a good time to look for them. I have often run across the egg masses when gathering the loosely deposited spawn of Mummychogs, *Fundulus heteroclitus*. The crab's eggs are in the mud, under the eggs of the fishes, close to the stems of the grasses which grow in such places.

Owing to their position, they are not always submerged, and each time the tide recedes they are drained, although they never become dry. In rearing these crabs, it appears to be necessary to reproduce these conditions, which I have accomplished by alternately bathing and draining the eggs, which are kept in a bottle of salt water, which is introduced and removed from a container from day to day according to the tides.

Each time the fresh salt water bathes the eggs, each young crab will be seen to commence moving about within its sphere, its tiny branchial plates fanning back and forth quite rapidly, an action which doubtless bears some relation to the introduction of the water.

When the artificial tide goes out, the crabs settle down once more. For best results in hatching the young, the eggs should also be kept in the dark except when observations become necessary.

Young Horseshoes emerged on July 16th from eggs deposited on July 1st. They hatched when the real tide and consequently the artificial one of their bottle was in, and the white envelopes of their eggshells floated to the surface afterward. (Fig. 48.)

Great activity ensued, as though the youngsters were unhappy and searching for some condition that I had not met properly for them. It suddenly struck me that I had not thought of providing a natural bottom for them. Accordingly I changed them at once with a dip-tube to a fresh tank with a good bottom of sand and mud. Instantly the entire mob dug themselves out of sight, where they afterward remained.

When free in the water, the youngsters propel themselves by forward and backward movements of the plates located under the posterior division of their shields. They differ from the old crabs in not having any tails, but the stub of one similar to the pointed, folded-in process of true crabs may be seen. This is raised, however, rather than folded in. It measures three and one half millimetres in length at birth.

In August and September, minute but perfectly formed Horseshoe Crabs are washed ashore in large numbers along the coast. Some of these are not more than six millimetres in length, but at this time their tails are fully formed, so they evidently do not remain buried in the sand for very long after they dig in. (Fig. 47.)

It has been observed that the young crabs disappear as soon as they



Fig. 47. Young Horseshoe Crabs, *Limulus polyphemus*, after their tails have become functional as a defence. Life size.



Fig. 48. Newly hatched and hatching Horseshoe Crabs, *Limulus polyphemus*. Note that at this stage they possess no tails. Much enlarged.

leave the eggs and are not seen again until considerably larger, and my simple observation mentioned above solves this little mystery. In burying themselves, the crablets are avoiding death at the hands of numerous enemies. They stay buried most of the time, until the spike-like tail becomes functional as a defence.

CHAPTER X.

THE COMMONER MOLLUSKS

THE name Mollusca is the scientific one given to that great Phyla which includes the marine and fresh-water shells, the land snails and slugs, and the squids and octopi. The latter two families are by far the highest types of mollusks, far removed in intelligence and in the development of special senses from their lowly cousins, the clams and oysters, snails, and other familiar types.

Most of the water forms of mollusks breathe by means of gills, but some of the fresh-water varieties and all the land forms have developed a pulmonary sac or lung for this all-important purpose. Thus we see why certain fresh-water snails come to the surface periodically, for they are true breathers of the atmosphere.

The shells of mollusks are secreted by the outer skin of the animal, the only exception being those shell-less species known as the slugs and the cuttlefish and octopi.

These creatures usually lay eggs, which are deposited on plants and seaweeds and stones, or under sheltering objects in the woods, as is often the case with the land snails. The bivalves, or two-shelled types, such as the oyster, the clams, and mussels, retain their eggs within the shell until they are hatched, and the young in such cases are often free-swimming, almost transparent creatures, utterly unlike the parents. (Fig. 49.)

The clams, oysters, and mussels feed upon micro-organisms which are sucked in through a tube extended especially for that purpose. The tiny marine forms of life are filtered out of the water that is drawn in, and the waste fluid is shot out through another tube. Thus, if we watch the water just above a bed of buried clams, we will see the streams of waste or filtered water shooting upward from the ends of the tubes which project just above the surface of the mud or sand.

The univalves, or single-shelled mollusks such as the snails, are of two kinds as regards their food. One group are fitted with long tubes or siphons through which they draw water into the gills and these are mostly carnivorous, some of them attacking and boring through the shells of other mollusks. Those univalves without a siphon projecting from beneath their shells are usually herbivorous.

It is very interesting to watch the scraping motion of the mouth of such a mollusk, and this may easily be observed by keeping a few snails in a

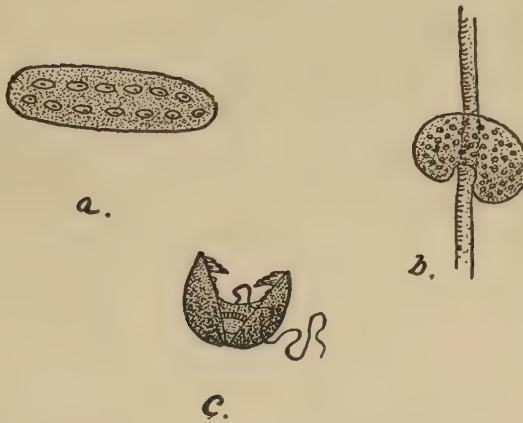


Fig. 49. Early stages of mollusks.

(a) and (b) egg capsules of fresh-water snails;
 (c) Glochidium stage of a fresh-water mussel.
 (Greatly enlarged.)

glass jar filled with water and watching them with a magnifying glass. As the sides of the jar become coated with *Algæ*, the snails will feed upon this substance and keep in good condition.

Molluscan faunæ have been divided into provinces, which are characterized by certain species. At the edges of these provinces, the species sometimes overlap, thus specimens of the Arctic province may be found as far south as Cape Cod, where they are able to live because of the influence of the cold Labrador current. In very deep water, which is extremely cold, Arctic species may also be found. Thus it will be seen that temperature plays a very important part in molluscan distribution.

The territory covered by this book lies in the Transatlantic province, with the Boreal province on one side beginning at Cape Cod, and the Caribbean province on the south beginning at Florida.

A few of our forms have worked their way beyond Cape Cod and a few of the Boreal species have worked theirs south of that cape into our province. Likewise when one gets below Cape Hatteras, some intermixture of Antillean species occurs.

The true Transatlantic species found within the area covered by this volume are not numerous or striking, and only those which are often met with or otherwise conspicuous in some manner have been figured and treated in the rest of this chapter.

There are numerous other provinces besides those that have been mentioned, and the one who is really interested seriously in the mollusks will do well to take up this fascinating subject of distribution. He will find, for instance, specimens that are identical on both sides of the Atlantic and many other interesting facts that will add fuel to his fire of enthusiasm.

FRESH-WATER MOLLUSKS

The univalve, or single-shelled fresh-water species are classed as Gasteropoda, commonly called snails, while the bivalve varieties, such as the mussels and clams, are members of the Lamellibranchiata. These last differ chiefly from the Gasteropods in that they possess no head or tentacles or eyes and no radula (chewing apparatus), and in that their shells are composed of two hinged valves.

Our two commonest Gasteropod pond snails are *Lymnæa palustris* Müll. and *L. columella* Say. (Figs. 50 and 51.) These are various shades of brown and yellowish brown, generally darker toward the top of the spire. This is especially true on *L. palustris*. The two snails are common in most of our ponds, and those of small size with muck bottoms and plenty of vegetation seem to be preferred.

When the animal of *Lymnæa* is extended, two conical tentacles will be seen, near the bases of which are the oval black eyes, mounted on short tubercles.

Their eggs are deposited in flat capsules of jelly. Within this mass,



Fig. 50. Fresh-water snails, *Lymnaea palustris* Müll. Life size. This is a common pond snail.

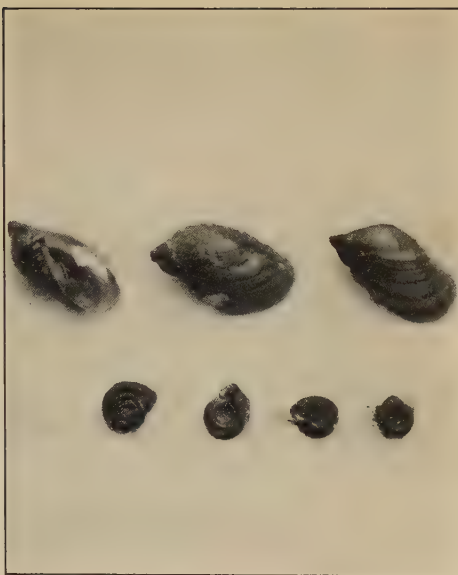


Fig. 51. Common fresh-water snails. *Lymnaea columella* Say, at top; *Segmentina armigera* Say, at bottom. Life size.

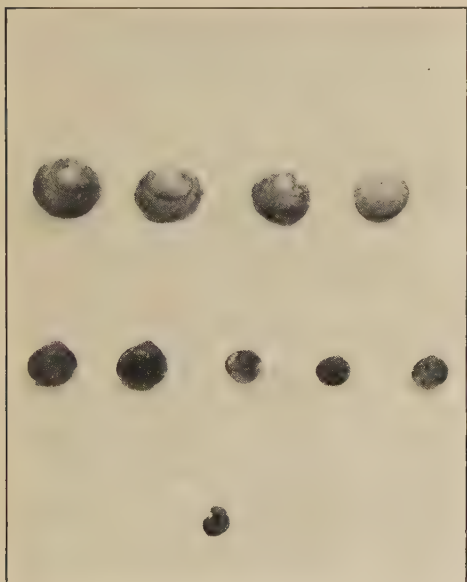


Fig. 52. Common fresh-water mollusks. (Top): *Musculium*; (centre): *Pisidium*; (bottom): *Planorbis exacuus* Say.



Fig. 53. A common fresh-water mussel, *Unio Complanatus* Dill. One half natural size.

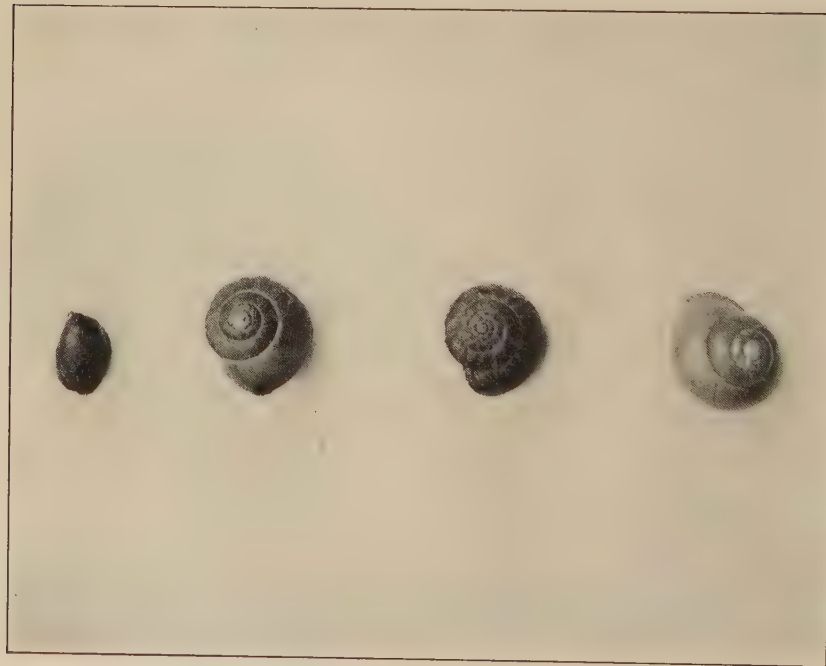


Fig. 54. Common snails (Terrestrial), (top): *Succinea ovalis* Say; (second row): *Polygyra thyroides* Say; (third row): *Pyramidula alternata* Say; (bottom): *Helix hortensis* Müll. Two thirds life size.

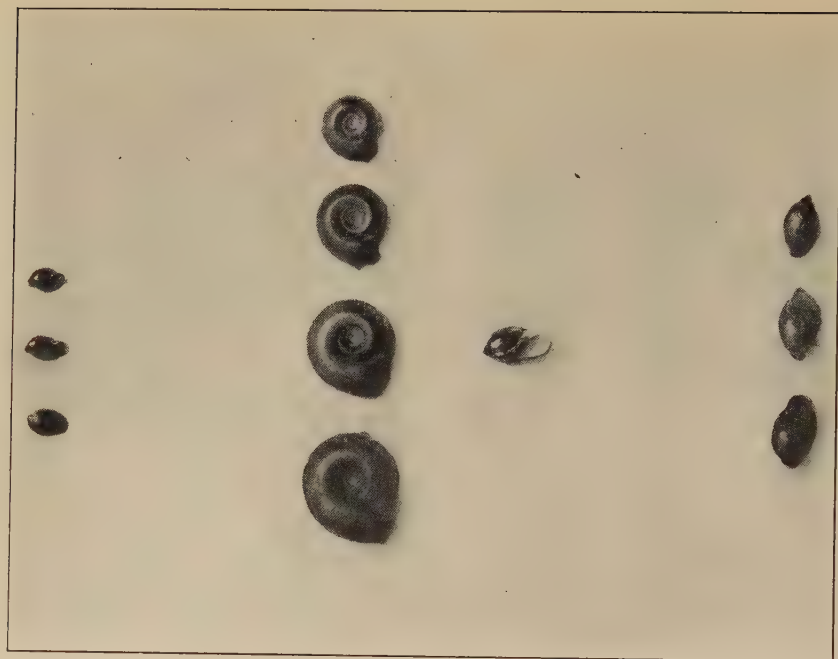


Fig. 55. Common snails (Fresh-water), (top row): *Physa ancillaria* Say; (second row): *Planorbis trivolvis* Say; (third row): *Physa ancillaria* Say; (bottom): *Physa gyrina* Say. Two thirds life size.



Fig. 56. The introduced slug, *Limax maximus* Linn., may be four to six inches in length and is very destructive.



Fig. 57. The common slug, *Limax agrestis* Linn. Note the breathing orifice and the mucous-covered skin.



Fig. 58. A life-size picture of *Limax maximus*, showing the orifice that leads to the creature's lung.

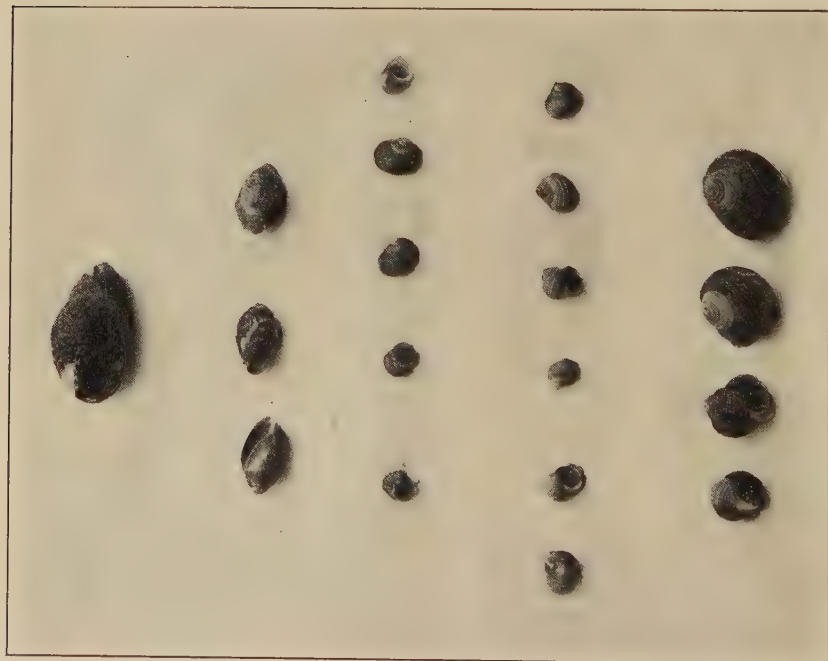


Fig. 59. Marine mollusks. (Top row): *Alectrion obsoleta* Say; (second row): *Melampus lineatus* Say; (third row): *Littorina obtusata palliata*; (fourth row): *Littorina rudis* Don; (bottom row): *Littorina litiorea*, Two thirds life size.



Fig. 60. Marine mollusks. (Top): *Acmaea testudinalis* Müll.; (centre): *Crepidula fornicata*; (bottom): *Urosalpinx cinerea* Say. This last species is the well-known Oyster-drill. Slightly reduced.

fifty or more eggs will be found. They are attached to water plants, and the development is quite rapid and may be watched to advantage with a powerful magnifying glass. As the development advances, the embryo snail will be seen to rotate within its egg capsule, which it continues to do while in this stage.

Another common pond snail is *Planorbis trivolvis* Say. (Fig. 55.) The shells of these snails are more or less flattened and coiled up like the spring of a watch. In colour they are yellowish brown or horn on the outside, and distinctly bluish white within. The animal possesses long delicate tentacles instead of the short triangular ones of *Lymnæa*.

These common snails inhabit ponds and slow-running streams and will frequently be found floating upside down with the foot extended upon the surface of the water. At such times they are taking in a fresh supply of air and expelling the gases from the poisoned previous supply. The Planorbs possess a lung like the land snails and therefore find it necessary to come to the surface at intervals.

These snails have the power of resisting drought to a considerable extent by sealing themselves within their shells if the pond dries up. In this sealed chamber they may live for a long time until fresh rains flood their habitats again.

Planorbs feed upon vegetable matter. Their egg capsules are few in number and contain only a few eggs each. They are deposited in the spring and early summer and the young hatch from them in about fourteen days.

Besides this common species, there are two members of the family frequently met with in our local ponds. Both are very flat and dark brown, and very much smaller than the foregoing species. They are *Planorbis parvus* Say and *P. exacuus* Say. (Fig. 52.) They inhabit ponds, and the latter may be found in the tiniest springs whose only source of water supply appears to be a subterranean one.¹

Two of the first clear pond or river snails that the student will find are *Physa gyrina* Say (Fig. 55) and *Physa ancillaria* Say (Fig. 55). These two

¹Another small dark-coloured species resembling a Planorb and a common mollusk in ponds is *Segmentina armigera* Say. (Fig. 51.) A full-grown specimen measures slightly less than a quarter of an inch across the shell.

species are energetic creatures that move much more swiftly than *Lymnaea*. Their shells are highly polished, olive or yellowish brown, and may be distinguished from the other common pond snails at a glance by the fact that the aperture is upon the left side of the shell. This opening is upon the right side in all the others except *Aplexa hypnorum*, but this species is much more slender than *Physa* and not so likely to be found.

Physa deposits its eggs in long, narrow jelly capsules and the individual eggs may number well over a hundred. The capsules are attached to stones or water plants, and may be found in spring and summer.

An extremely interesting and common group of our fresh-water mollusks are the clams and mussels. The most abundant local species is *Unio complanatus* Dill. Full-grown specimens will measure up to four inches, and possibly longer, and when as large as this the mollusk may be ten years of age. If you look closely at a fresh-water clam or mussel, you will see distinct or obscure lines running around the shell, interspersed with narrow darker lines. Each of these darker lines represents a rest period, and by counting them we may determine the approximate age of the animal, each dark line representing a year.

The interior of the shell of one of these mussels will be found to be lined with a mantle or skin. The cells of this mantle extract carbonate of lime from the blood of the mollusk, and from this the shell is built up, layer upon layer along the outer edge.

Unio complanatus will be found in many of our clear-running streams almost entirely buried in the sand and mud. Here it arrives by means of its muscular foot, which is an appendage specially fitted for burrowing into the stream bottom. When buried in a satisfactory environment, the valves of the shell are partly opened and the two very short siphons are projected into the water. Through one of these the animal draws in water and its contents of microscopic plants and animals. From this water the food is sifted and digested and the filtered fluid is ejected through the other siphon. If you will place a mussel in a jar with a sand bottom several inches deep, and fill the remainder of the space with water, you will soon observe the mollusk in the act of burying itself and will see the ejected and injected water streams as soon as the mussel is settled.

This species is dark brown or brownish black with rusty patches and streaks upon its shell. This is the colouring when the shell is dry. The mantle which projects slightly around the edge of the shell is yellowish brown with a shining silky appearance. The upper part of the shell is almost invariably partly eroded, exposing the pearly texture of the shell below. Within, the two valves are pearly and iridescent, and the general colour scheme may be purple or salmon or bluish white, and very beautiful.

The gills of these mussels have been evolved in such a manner that they act not only as breathing organs, but as pouches for the young as well. In these pouches the eggs of the mollusk develop into strange little objects known as the Glochidium stage. They are more or less rounded capsules, within which the embryonic shells of the mussel may be seen. Between these shells or valves a long thread-like object develops called the byssus and the margin of each valve is fitted with a saw-toothed hook. (Fig. 49.)

The young are finally discharged from the pouches of the parent mussels and may then fasten themselves to a stone or, as in the case of some species, to a living fish by means of their toothed hooks. If this be the case, the living tissue of the host grows around and finally completely covers the young mussel. Here it lives until its digestive organs, heart, and gills are fully developed and it is able to break out of its fleshy prison, where it has been encysted, and care for itself.

Swarming in ponds, ditches, lakes, and springs are two tiny forms of mollusks resembling minute clams. The shells are pearly white or tinged with pink, but this colouring is often covered by a coating of brown or reddish brown, due to the mud or water inhabited.

The species of the genus *Musculium* Link have rounded, thin shells and measure three eighths of an inch across in a large specimen. The commoner genus *Pisidium*, C. Pfeiffer, are still smaller, some of them minute, and they may be easily distinguished by their inequilateral shell. (Fig. 52.)

A net scooped into the mud of any pond or muddy spring will yield a number of these little "clams." If placed in a jar of water, they will be seen to move all about up and down the sides of the glass and along

the under surface of the water. During these movements their long single siphons will be seen projecting far beyond the animals' shells.

Undoubtedly these little mollusks form an important item of diet to many aquatic creatures as well as to ducks and sandpipers, and they must be indeed tender and tasty.

Little or nothing appears to be known concerning their life histories, probably because of their small size, but this should not deter the enthusiast, and here is a productive field for the investigator.

TERRESTRIAL MOLLUSKS

The terrestrial species, or land snails as they are commonly called, are air breathers and possess a lung, which consists of a sac reticulated with blood vessels. Owing to this fact they are called the Pulmonata.

The commonest land snails locally are *Polygyra albolabris* and *P. thyroides* Say. (Fig. 54.) They may be found in damp woods, under bark and stones or old logs. In the fall they draw themselves within their shells, and after stopping the aperture with mucus, which hardens into a firm cover, they remain in a torpid state until spring.

Polygyra albolabris, when full-grown, measures about an inch across the widest part of its shell. It is yellowish brown, or slightly pinkish, with a broad white lip around the aperture. The animal is white or creamy white, and twice as long as the shell.

This snail deposits whitish masses of eggs in leaf mould or under rotting logs and stones. The young emerged from a batch of eggs, found on June 15th, just twenty-five days later.

Polygyra thyroides is a smaller species, measuring one half inch, or somewhat more, and is yellowish brown, but usually darker than the former species. It is found in moist places in the woods under leaves, bark, or stones.

Another little land snail often met with is *Succinea ovalis* Say. (Fig. 54.)

As its name implies, the shell is more or less amber coloured (or yellowish brown). The animal is not entirely covered by the shell at times, and distinct marks of growth may be observed, the edge of the shell often being very fragile and much frayed.

This snail is usually found near ponds or swamps and is perhaps partly



Fig. 61. Eggs of the common snail, *Alectrion obsoleta*, greatly enlarged. They appear like glass boxes with many sides, through which the development of the young snails may be watched. The eggs are common in brackish water in spring and summer.

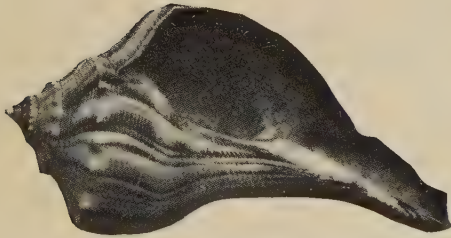


Fig. 62. The common Periwinkle, *Fulgur carica* Linn. This is a young specimen, about one quarter grown.

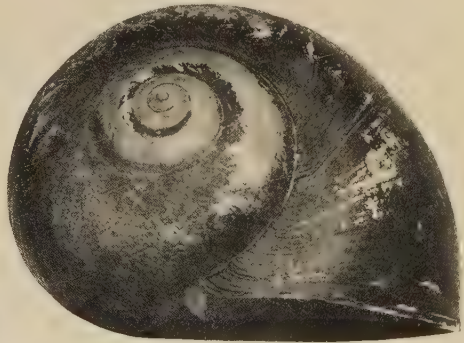


Fig. 63. *Natica heros*, the snail that constructs the familiar "sand-collars." One half life size.



Fig. 64. Marine mollusks. (Top row): *Venus mercenaria* (Hard clam); (second row): *Mya arenaria* (Soft clam); (bottom row): *Ensis directus* (Razor clam). One half life size.



Fig. 65. Marine mollusks. (Top row): *Haminea solitaria*; (second row): *Eupleura caudata* Say; (bottom row): *Urosalpinx cinerea* Say. Life size.

aquatic, forming a link between the truly aquatic and truly terrestrial species. I have found it at other times under stones and leaves which were not in the vicinity of fresh water. The eggs of this species are deposited in glutinous bunches upon the stems of plants often close to the water's edge, the young emerging in from fifteen to twenty days afterward.

SLUGS

The Slugs, which we all recognize at sight, are mollusks or snails that have apparently lost their protective shells. In reality many of them possess a rudimentary shell which, however, is covered by the mantle on the front part of the creature. This mantle appears like a saddle behind the head. A search by dissection in this mantle will usually reveal a delicate shell of some sort.

Slugs are destructive creatures, feeding upon fruit and vegetables, leaves and refuse, and sometimes cause considerable damage in greenhouses. They may be found beneath logs, or leaves upon the ground, among vegetables, or under any convenient object in damp cellars. Reproduction is by means of eggs deposited under stones, leaves, or refuse.

The reproductive orifice is situated behind the base of one of the upper tentacles on the forward part of the mollusk. Another orifice, situated farther back and plainly visible upon the right side, is the breathing hole which leads to the lung. The tentacles may be two or four and the upper pair are longer, bearing the eyes.

When slugs move about they leave a silvery path of mucus, and their tracks are easily distinguished. This mucus is very thick and heavy and is used as a protection against dryness, a condition which no slug may stand for long.

One of the commonest local species is *Limax agrestis* Linn. (Fig. 57.) In length this slug measures from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches. The body is quite smooth and varies from yellowish brown to chocolate or cocoa colour, usually brighter on the mantle. The flesh surrounding the breathing orifice is lighter than the rest of the mantle. Close inspection shows the body to be indented with fine darker lines forming a reticulated pattern. The under surface is yellowish white and more or less translucent.

Limax maximus Linn. (Figs. 56 and 58) is the largest species found here. It is an introduced European species which reaches a length of four to six inches. It is rough and shining and its back is covered with coarse wrinkles. The ground of the body is yellowish and grayish white, and this is thickly marked with brown and black. These dark markings are in the form of rounded spots and narrow disconnected stripes. The two largest tentacles are pinkish brown, and are covered with minute brown dots. Most of the body surface is rough, appearing as if made up of hundreds of tiny slugs side by side. The under surface is yellowish white.

This slug is often met with in cellars, if they be damp, and it is a greedy feeder that destroys leaves, vegetables, and even meat and other household foodstuffs.

The rudimentary shells that lie under the mantles of these slugs are very interesting and, although invisible from without, they may be easily obtained clean and free from animal matter by the following simple method:

In a test tube place one or two sticks of potassium hydroxide and dissolve them in a small amount of water. Now cut the mantle from the killed slug, leaving an eighth of an inch of flesh below it. This may be done with a pair of sharp nail scissors. Drop the mantles in the solution of potassium and boil very carefully over an alcohol burner until all animal matter is dissolved. Pour the discoloured solution in a dish and add some clean water. You will now find the flattened white shells, which may be collected and dried. If the slugs are of small species they may be put into the solution entire.

Limax agrestis has a flat shell showing rings of growth, and resembles a flat oyster of minute size. The shell is white. *Limax maximus* possesses a much larger shell, which is more cupped and of a beautiful pearly white colour.

MARINE MOLLUSKS

In this section of the present chapter I have given short descriptions and clear illustrations of the commoner marine mollusks, which are found along the beaches washed up by the tide, or below the low-tide

mark, still living in the water. Others, such as the Littorinas, will be found among the stones and tide pools upon the sloping beaches, or in seaweed growing along the rocky shores. The brackish inlets are also populated by a few species, especially *Alectrion obsoleta* Say, which swarms in such places.

The marine Gasteropods or univalve species will be treated first, followed by the Pelecypods or bivalve forms, such as the oysters, scallops, and clams.

The Gasteropods, whether marine, terrestrial, or fresh-water, are possessed of a ribbon which is covered with rows of teeth of various shapes and sizes according to the group to which the animal belongs. This is called the lingual ribbon and is situated in the throat of the mollusk. It may be obtained easily by dissolving the animal in potassium hydroxide solution as explained on page 68, for obtaining the shells of slugs, and it will repay the investigator to examine a number of these ribbons under the low-power lens of the microscope. Gasteropods feed upon animal and vegetable matter, which must be rasped, and therefore they have been fitted with these toothed ribbons, whereas the Pelecypods usually feed by filtering the microscopic plants and animals from the water, which then go directly to the animal's stomach for digestion.

Haminea solitaria (Fig. 65) is a small bluish-white and extremely fragile shell sometimes found in large numbers washed up on the beach in summer. It varies in colour, some being almost gray or brown, but always with a high polish.

Acmæa testudinalis Müll. (Fig. 60.) The limpets or "Turtle-shells" are very common along the New England shore. They cling to rocks or other shells and are very difficult to remove until the suction disk is lifted with a knife. Limpets feed upon vegetable matter which grows upon the rocks, such as Algæ. They have rounded or oval conical shells and are usually attractively coloured and patterned. A smaller limpet, *Acmæa testudinalis alveus*, is common on the stems of marine grasses. It is spotted with brown and white and may easily be found by the patient searcher.

Natica heros (Fig. 63) is a big and easily studied mollusk, which must be looked for in pools left by the receding tide. It is much commoner on

Long Island than on the Connecticut shore, but may be occasionally found. In colour it is grayish white to brown, medium-sized specimens as shown in Fig. 63 being covered with a yellowish-brown skin which covers the shell. This mollusk is carnivorous and cannibalistic, feeding upon other mollusks or on dead matter.

Many of us are familiar with the beautifully constructed "Sand-collars" which are found upon the beach in summer. These objects, which really do resemble a collar, are made of sand grains cemented together by this mollusk, and within which it deposits its eggs in a sort of jelly.

A shell frequently picked up upon the beach is *Crepidula fornicata*. (Fig. 60.) The fact that the shells of this genus are called "Boat shells" needs no explanation. *C. fornicata* is faded white, often with a row of dark spots around the rim upon the lower surface. The shells of this species are often found upon the beach, but in life they cling to the shells of other mollusks. *Crepidula plana*, another species, is white, with a square stern, a point which distinguishes it locally from the other form.

Littorina litorea (Fig. 59) is one of the most abundant local marine species. Although supposedly an introduced European species, it is now very common along our shores, where it gathers in large numbers upon rocks that have been uncovered by the tide. It also swarms among the wet stones on pebbly beaches. In colour the shells are variable. Some are black, others olive, yellowish brown, or shades of gray. The ground colour is crossed by circular bands of black and brown, and the left-hand side of the aperture has a broad white margin. The upper whorls of the spire are often of a lighter colour than the rest of the shell.

Littorina rudis Don (Fig. 59) is smaller than *litorea*, with encircling grooves alternating with encircling ribs. It is gray, yellowish, or pinkish. The best place to search for this species is among seaweed attached to rocks that are alternately bathed and uncovered by the tides.

Littorina obtusata palliata Say (Fig. 59) should be looked for in the same habitat, where it mimics the colour of the seaweed to a remarkable degree. Some are olive-green, others bright yellow, or red with darker bands. It is an extremely beautiful species. It is a smoother, more globular species than the two preceding, with a much lower spire. Locally, this species and *L. rudis* are always associated in the author's experience, and

are exceedingly common among the Algæ-covered rocks about Scott Cove at Noroton.

Melampus lineatus Say (Fig. 59) is an abundant amphibious snail that is found commonly among the salt hay and grasses of salt marshes and among the eel grass which borders the inlets. It is light olive brown or yellowish brown, the upper surface of the shell being usually stained, eroded, or hidden by a sort of epidermis. The true colour may be seen about the aperture, and here there are often bands or streaks of darker yellowish brown. This species appears to be most at home when uncovered by water.

Urosalpinx cinerea Say (Fig. 60), the Oyster-drill, is a well-known pest. It drills a hole in an oyster or some other mollusk by means of its powerful lingual ribbon and sucks out the substance of its victim. The shell may be gray or yellowish brown with many revolving ribs and grooves, crossed by larger and coarser ribs and grooves running from the base of the shell to the tip of the spire.

Eupleura caudata Say (Fig. 65), closely related to the last-named species, is a beautiful little white or gray shell. I have found it among the rocks and stones just beyond the low-tide mark, where it appears to feed upon smaller mollusks much as the Drill does. The shell is less than one inch in length with distinct longitudinal ribs and grooves. The lip of the shell on the right-hand side of the aperture is flat and comparatively broad.

Alectrion obsoleta Say (Fig. 59) is one of the most abundant of our local species. On the muddy bottoms of the inlets it will be found in hundreds of thousands; so thick are they at times that at low tide the inlets appear like sheets of rusty metal studded with millions of black rivets.

It is very difficult, despite their numbers, to obtain a full-grown and perfect shell of this mollusk. For some reason they are almost invariably badly eroded and the spires eaten and disfigured by the action of the water. The shell may be almost black or olive and occasionally bluish. Within the aperture the colour is black and purple, and it is highly polished. The animals feed upon vegetable matter and their eggs are beautiful transparent boxes whose sides appear as if made of glass. (Fig. 61.) These are deposited in strings or masses in spring, upon stones, dead

leaves, grasses, and sticks, and are one of the most familiar objects of the shallow inlets in June.

The best known large shells along our coast are the Periwinkles, *Fulgur carica* Linn. and *F. canaliculata*. The first of these (Fig. 62) reaches eight or more inches in length and may be identified by the blunt horns or nodes which project at various points around the top part of the shell and by the bright red colour of the aperture. In young specimens the shell is yellowish white with darker streaks placed longitudinally as shown in the figure.

Fulgur canaliculata, the other common species, is not ornamented with nodes and is light gray and covered by a brownish epidermis. Both of these species occur at Shippan Point at Stamford and doubtless may be found almost anywhere along the shore.

The egg strings of the Periwinkle are familiar objects upon the beach, being a series of tough, yellowish parchment-like capsules attached to a stem at the back of the string. Within these capsules hundreds of tiny but perfect Periwinkles will be found. (Fig. 69.)

The Pelecypoda or bivalve mollusks differ principally from the Gastropoda in that their shells are made up of two similar parts joined together by a hinge and opened and closed by means of strong muscles. The Pelecypoda, as the name implies, usually possess a more or less hatchet-shaped foot, with which they bury themselves in the mud or sand. They differ anatomically in that the majority possess no head, eyes, or tentacles, but possess labial palps and modifications in some of their other organs. These mollusks feed by drawing in water laden with microscopic organisms, filtering out the edible matter, and ejecting the spent water. This process is accomplished by means of two tubes or siphons of various lengths according to the species, and it is from these extended tubes of clams that the familiar squirts of water issue from the sand as we walk along the beach. The water drawn into the animal also bathes the gills and the oxygen is extracted from it.

Mussels are familiar to all of us, but it is, perhaps, not generally known that we have more than one common species. They do not as a rule bury themselves like the clams, but instead congregate in dense masses on rocks and piles, although some of them seek the tough sod at

the edge of the salt marsh. Within the mussel is a gland which secretes a number of tough strands with stellate tips, known as the byssus, and which acts as an anchor to the mussel. If you pull a mussel from its position, you will see this byssus at once.

The big common mussel is *Modiola modiolus*. (Fig. 67.) Its shell, when freshly cast upon the beach, is covered by a hairy coat, and if you will break or open the valves, the animal will be found to be coloured a beautiful orange. This species occurs in deeper water than the next, and more familiar, form.

Mytilus edulis (Fig. 67) is the mussel which we see in dense masses in shallow water or upon rocks and piles that have been uncovered by the retreating tide. The shell is black or deep blue and it never reaches the great size of the preceding species. Among the masses of mussels many specimens will be found whose shell is quite different in colour from the rest, being alternately marked with yellow or green overlaid with black rays. This is a variety of *Mytilus edulis* called *Mytilis pellucidus*. Some of the shells of this variety are extremely beautiful and should be hunted out by the collector.

The third common mussel, *Modiola plicatula* (Fig. 67), inhabits the mud and sod about the edges of salt marshes and the banks of sloughs which are covered by the tide. It is rather long and narrow and may be identified at once by its ribbed shell.

Many of the bivalve mollusks are so familiar that they need no description. The Oyster, *Ostrea virginica* Gm. (Fig. 66), is one of these. The young might be overlooked, however, as they are extremely flat and smooth-edged. They may be found adhering to stones and other shells in shallow water. The mature oyster deposits a million or more eggs from which issue, at first, free-swimming young. These attach themselves after a time to some submerged object, and here the mollusks spend the rest of their lives.

Another familiar shell is the Scallop, *Pecten irradians* Lam. (Fig. 66.) This is the mollusk which supplies the tasty and expensive scallop of the market, but it is not the entire animal which we fry and eat with such relish. It is only the adductor muscle which is cut out of the shell and sold as food.

Scallops are very remarkable mollusks when compared to most other familiar species. They are capable of swimming about in a zigzag course at any time, the wild movements being possible because of the creature's ability to open and close its valves rapidly. The scallop when open reveals a row of eyes which certainly are capable of vision, as it will sometimes dart away from an approaching shadow or an uplifted hand on the outside of an aquarium. The enthusiast should obtain some live scallops if possible and keep them long enough to observe their orange mantles studded with bright blue eyes.

The Round or Hard-shell Clam, *Venus mercenaria* (Fig. 64), is another of the most familiar mollusks. It lives in the mud of inlets or bays or in the sandy bottom of the shore, and is, of course, taken in enormous numbers for the markets every year. Its siphons are short and vastly different from the other common clam, or Soft-shell, *Mya arenaria* (Fig. 64), which is used so extensively for steaming. The latter species buries itself deep in the mud and sand and stretches its long "neck" containing the two siphons clear to the surface of the bottom. Here its presence is known by the holes that stud the vicinity. When the tide is in the clam sucks the fresh food-laden water into its stomach and ejects the filtered portion through the other siphon. Some of the soft clams take up positions which are never uncovered by the water, while others are found where they may be without a water supply for several hours.

The Soft-shell Clam is of a longer and narrower shape than the rounded Hard-shell. It is softer and quite brittle and is incapable of closing as tightly or as completely. The siphon protrudes somewhat, even after the shell has been picked up and the mollusk has reacted to the disturbance.

Sometimes we find long narrow yellowish shells upon the beach which are those of the Razor Clams, *Ensis directus*. (Fig. 64.) They are edible but not delicate, and are used to some extent for chowders. The siphons of this mollusk are not united in a single neck as in the Soft-shell Clam. Another common shell somewhat similar to the Razor Clam is that of *Tagelus gibbus*. It has an elongated narrow shell rounded at both ends and two separate, extremely long siphons. The shell is really whitish, but the epidermis which covers it gives it a yellow colour.



Fig. 66. Marine mollusks. (Top): *Ostrea virginica* Gm. (Oyster); (bottom): *Pecten irradians* Lam. (Scallop). One half life size.



Fig. 67. Marine mollusks. (Top): *Modiola modiolus*; (centre): *Modiola plicatula*; (bottom): (left) *Mytilus pellucidus*; (right) *Mytilus edulis*. One half life size.

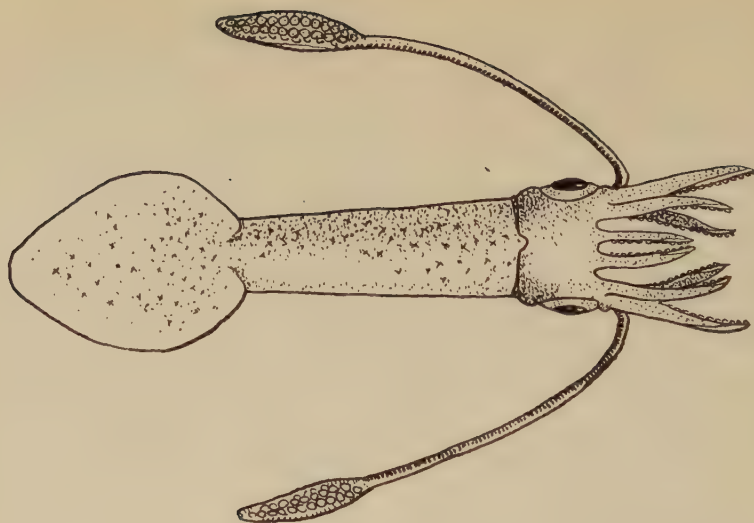


Fig. 68. The common squid, *Loligo pealei*. (One third life size.) Squids are a much higher type of mollusk than clams, oysters, and snails.



Fig. 69. Portions of egg capsules and young of a Periwinkle. The egg capsules are found in long strings on the beach. They are shown here about life size.

Occasionally, we find a piece of floating or water-logged wood bored in every direction with holes of small diameter. If we split this wood, the holes are found to contain either living worm-like mollusks or the shelly linings left in the tubes by them. These tubes are the work of the Ship Worm, *Toredo navalis*, a creature which is responsible for a great deal of damage to piles, wharfs, and shipping.

The living animal is possessed of a small bivalve shell at the large end of the tube, and at the small end or entrance two siphons project into the water through which the creature feeds. It bores holes cleanly but no one has been able to tell just how, and here is an interesting subject for investigation.

THE SQUIDS

These creatures belong to the Cephalopoda, the highest class of mollusks. They are vastly superior to the forms which we call snails, clams, and mussels, but their relationship is quite clear anatomically.

The class includes the Devilfish, Octopi, Argonauts or Paper Nautilus, and the Squids or Cuttlefish.

We are concerned only with the common Squid, *Loligo pealei*. (Fig. 68.) It might be confused with a small octopus by the unobservant, but the fact that it possesses ten arms instead of eight would at once separate it as a Decapod.

Our species, which is often stranded upon the beach, has a cylinder-like body which tapers off toward the tail end. It is supplied with large staring eyes and ten arms, two of which are long, and all are fitted with suckers.

Squids change colour almost instantly and the changes are so numerous and varied that the animal appears to be in the beam of a rapidly changing coloured flood light. These changes are brought about by the opening and closing of pigment cells.

When disturbed or frightened, Squids expel an inky fluid which instantly clouds the water and hides the mollusk from view.

The food of the Squid consists of small fishes which it catches with its long sucker-studded arms. This species reaches about one foot in length and ranges along the coast from Cape Cod south to the Carolinas.

CHAPTER XI

OUR FRIENDS THE SPIDERS AND MILLIPEDES

THERE are two facts that the uninitiated should know about spiders at the outset. One is that they are not insects and the other is that the vast majority of them are not only harmless, but are helpers of mankind in every sense of the word, destroying, as they do, large numbers of other insects many of which are distinctly harmful.

Spiders belong to the Arachnida, and are related to the lobsters, shrimps, and crabs. Despite this they are almost always called insects by the layman, but may at once be distinguished from the insects by the presence of eight legs instead of six. The familiar Daddy-long-legs, or Harvestman, is also a near relative of the spiders and is not an insect, as its eight legs will attest.

Nearly all the spiders with which we are familiar are harmless or at most capable of inflicting a slightly poisonous bite. They do everything possible to avoid aggressive contact with man. A convenient source of food supply is what brings them about our homes, and here they rid us of flies, mosquitoes, and insects of every description. Even the dreaded Tarantula of South America is among the spiders that are beneficial, and I have seen Tarantulas in camps remaining hidden during the day and venturing forth by night to prey upon the gigantic roaches that infest the houses. Tarantulas grow to a large size, but the people of the South do not often kill them, because of their predatory habits.

In British Guiana I have lived in a camp containing a dozen or more Tarantulas, which never disturbed me as long as I respected their feelings also.

The bite of the Tarantula is very much overestimated. In some few cases, where the person bitten has been weak or in a non-resistant condition, it may be that death has occurred from such a bite, but in cases

that I have seen and have suffered personally, it resulted in nothing more than a painfully swollen member accompanied by some fever, which, however, passed off without leaving any ill effects.

Of our common spiders, the Lycosids are of great interest. They live upon the ground and make no permanent web, running about from place to place and using any convenient hiding place for the time being. The egg case is carried about by the female, and when the young emerge they ride about upon the mother's back wherever she goes until fairly well grown. It is a common sight to see them thus in September. As the mother progresses, the youngsters may be seen moving about like tourists upon the deck of a steamer! (Fig. 72.)

Spiders are born from eggs most of which are very small. They are usually deposited in rather large numbers, as mortality is high among the young. (Fig. 70.) Some are placed beneath silken coverlets upon stones or boards, but the majority are deposited in clusters and afterward covered by a tough silken cocoon or other more ornamental contrivance. One species constructs a cocoon that resembles a withered fruit, while a South American species suspends its cone-shaped egg sac upon a long thread and covers the cocoon with spines of silk.

Young spiders usually shift for themselves as soon as they leave the cocoon and look very much like the adults except in colour. Within the egg cocoons the young hatch out some time before they break through into the outer world, and cannibalism is sometimes practised within the silken prisons. (Fig. 74.)

Many spiders are remarkably camouflaged. Through countless years the process of natural selection has been shaping and colouring some species until now they resemble entirely different objects that are perhaps not edible to spider enemies. One species closely resembles the excreta of a bird, while others have developed so many long sharp spines that they appear more like some vegetable burr than a spider.

Spiders are ravaged by minute and formidable enemies in the form of Ichneumon Wasps, and there are many species that attack them. These little insects belong to the Hymenoptera, the same order to which ants, bees, wasps, and sawflies belong. Ichneumons attack the eggs of spiders depositing their own minute eggs among those of their hosts. When

the maggot larvæ of the parasite hatch out, they devour the spider's egg and thus destroy the entire brood.

There is often a second species of Ichneumon depositing eggs upon those of the first parasite, so that the plans of the original destroyer are often frustrated. This is termed hyperparasitism and is one of the most interesting things in nature.

Wasps are other great enemies of spiders. These insects hunt and capture countless numbers of them as provender for their young. Some of the solitary wasps that build the well-known mud nests often pack each of their clay cells with thirty or more spiders of several varieties. In a single nest containing twenty cells, a huge number of paralyzed spiders may be found with the maggot-like young of the wasp feeding upon them.

In fall, many full-grown spiders and partly grown ones construct heavy silken covers in protected places, under stones or loose bark or in buildings, where they remain in a sluggish condition until spring.

Of the wonderful webs of spiders little need be said, for we are all familiar with them. It is, perhaps, a pity, though, that such a wonderful object as an orb web is such a common object and therefore so little appreciated. Many spiders renew the cross threads of their webs at night, leaving only the radii in place. This keeps the web in repair and the work is done when most spider enemies are asleep. They may be seen working at night in almost any vine or porch corner, where their intensely interesting building procedure may be studied to advantage by the aid of an electric flashlight.

Closely related to the spiders are the Millipedes or Diplopoda and the Centipedes or Chilopoda. These are the long, slender-bodied creatures with vastly too many legs. Millipedes have two pairs of legs on each segment that bears legs, while the centipedes have but one pair.

The commonest millipede is the big prettily coloured *Spirobolus marginatus* which curls itself up into a spiral tube when disturbed. Its legs are red and waves of motion travel along them as the creature progresses. Other smaller millipedes are common in old wood, under stones, and in the ground. Most of these also curl up when touched.

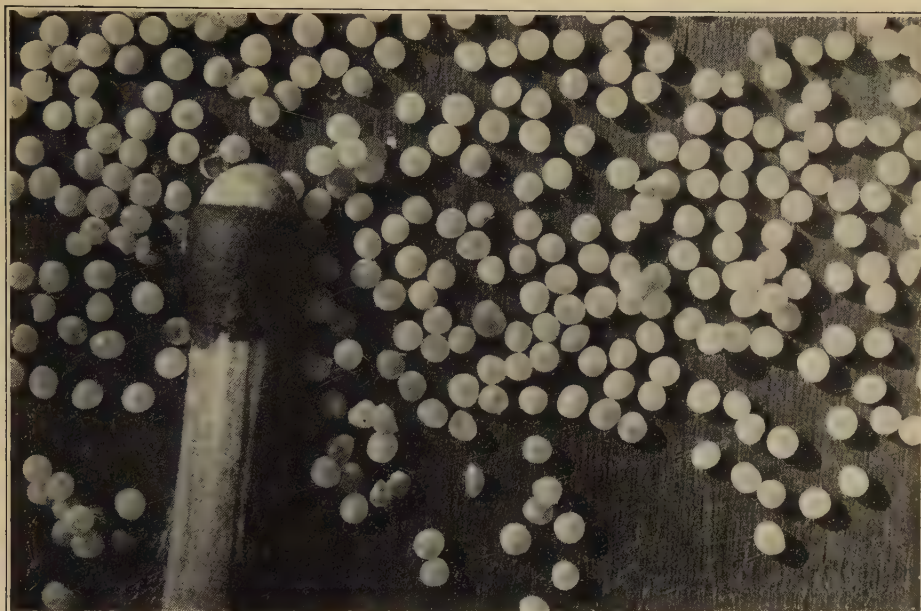


Fig. 70. The eggs of a common spider. The match head tells us the real size. These are from a single egg cocoon.



Fig. 71. A small and common spider of the backyard, highly magnified. Notice its numerous eyes of different sizes.



Fig. 72. A Lycosid spider with her brood of young upon her back. Twice life size.



Fig. 73. A remarkable photo of a young spider "ballooning" (spinning out long threads of silk until they pull sufficiently in the breeze to carry the spider through the air to pastures new).

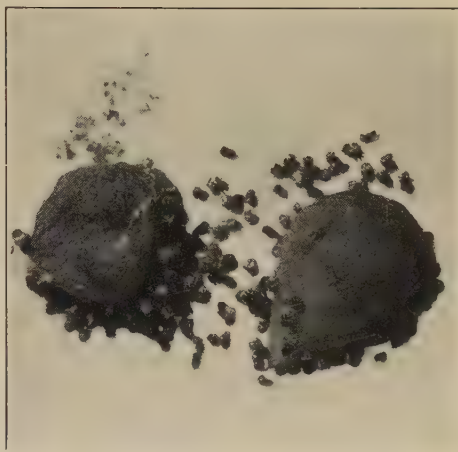


Fig. 74. A brood of young house spiders just bursting forth into the world from their silken cocoons. Cannibalism is doubtless practised in these cocoons during the winter.

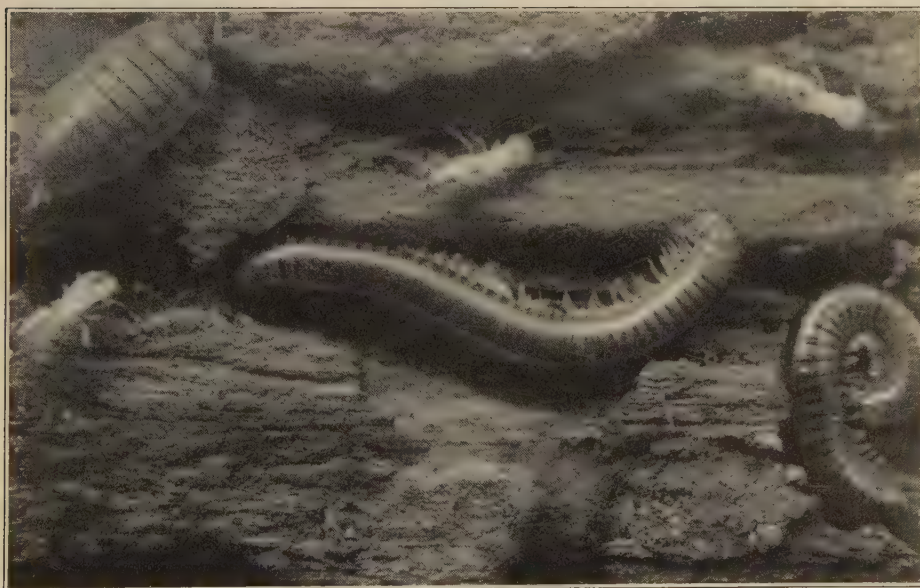


Fig. 75. Living forms found beneath a stone. Sow Bug, a terrestrial crustacean (upper left-hand corner), two millipedes, and three White Ants properly called Termites.



Fig. 76. A common centipede in houses is *Scutigera forceps*, shown here natural size. This creature often becomes trapped in tubs or basins.



Fig. 77. A common red centipede. Note that a centipede may be distinguished from a millipede by the fact that only one pair of legs are attached to each segment, whereas millipedes have two pairs on each segment.

Millipedes are harmless, and feed upon rotten wood and other vegetable matter. (Fig. 75.)

The centipedes are more or less poisonous, especially in the tropics, but our little local species appear to be quite harmless. There is one strange variety that is often seen in houses, but few people would imagine that it was one of the centipede outfit. This is *Scutigera forceps* (Fig. 76) and one of the strangest creatures in our midst. It is yellowish brown and possesses fifteen pairs of long legs, one pair of which are modified into "tails."

This animal has the habit of getting into bathtubs and wash basins, where it becomes trapped. It feeds upon roaches and other insects and is entirely beneficial, but its frightful appearance usually brings about its early death at the hands of the householder.

CHAPTER XII

HOW I PHOTOGRAPH INSECTS

A QUESTION that I have been asked by readers from many parts of the world, and particularly from Europe, is, "How do you obtain these results with such difficult subjects?"

Insects are, of course, difficult to photograph properly, not so much because of their small size, but especially because of their nervous energy and tremendous activity. If one really knows these creatures, however, he will have learned that, like nearly all living things, they, too, have their moments of relaxation and repose or even sleep. Further, he will have learned that, even during their attacks and high-noon activities, there come instants of slower motion that may be taken advantage of by the alert photographer.

To be properly equipped for such work does not mean that a very costly outfit is essential. In fact, I use no costly material whatever, so far as camera and lens are concerned, but the expense in exposed plates, which upon development do not come up to my standard, does mount up into considerable sums. My pictures to-day are the result of thousands of exposures, a great many of which have been discarded as failures. Whereas the experienced photographer seldom has a failure on ordinary subjects, insect subjects will baffle the best of us.

It will be well, before going on to incidents that come to mind, briefly to describe my outfit. I wear out a camera a year, an ordinary 5 x 7 Century, with long bellows and the usual rack and pinion adjustments and wherewithal for tilting, swinging, tipping up and down and raising and lowering the lens board. In this box, I have my very old and trusty Sweet and Wallach Automat shutter and an F 8 Planatograph lens that cost about ten dollars and which I would not give up for five hundred. This lens has taken all my best photographs. It has outworn ten boxes, crossed and recrossed the Andes, seen the Guianas and their rain forests,

blinked through California, and recorded the life of the Windwards. It has been wet and dry, frozen, and scorched in the heat of the tropics, and it has never failed me. It is a plodder; that is its only fault.

When I am photographing insects at close range, I use an Eagle enlarging lens that costs fifty cents. This fits over the regular lens and enlarges the object directly upon the plate. All this sounds very simple, but remember that, when using this device, the front of the lens is within a very short distance of the insect being photographed. Further, every move that the victim makes is greatly exaggerated upon the plate, and so one must only photograph still or very slightly moving objects.

Here I will let you into my first and very important secret of the work, the glass box. This is a square cabinet on short legs, with glass on four sides and the top. One of these sides is a hinged door and the bottom of the cabinet is of wood. The entire affair is ventilated, so that if placed in the sun the glass will not fog up too much. When I am ready to make photographs, I set the camera up close to the glass side of the cabinet, put on the enlarging lens, and make ready for quick work. Next I put a dirt floor in the box, together with several bunches of grass or weeds or whatever comes to hand. As a final step I drag a heavy net through the grass or foliage about me until I have a whole mob of insects within its meshes. These are now turned loose in the cabinet and the door closed.

When the first mad panic subsides, a patient worker will see that many of the insects are at rest. Here will be a Robber Fly that has brushed himself off and is resting in the full sunlight, a simple object to photograph. An ant, on finding a crushed nectar cup giving freely of its sweetness, has already forgotten its fright. Bugs are sitting about and things soon become quite normal.

It is now that the photographer has his chance to catch some bit of insect life. He may photograph directly through the glass, but he must be endlessly patient and know his lens and plates and the lights by heart. Glass-box photography has given me most of my best results.

When I endeavoured to photograph the nocturnal tree cricket I had to resort to a trick to fool the insect. This creature sings by holding its wings aloft and scraping them together, thus producing the flute-like notes. It was simple enough to catch the insects, but, as they only sing

at night, a difficulty arose at once. At length I hit upon the idea of placing the songster in a glass box of small dimensions that had previously been covered with a neatly fitting black cloth that was entirely light proof. The box and cricket were placed in bright sunlight, the camera set up and focussed upon the only support within the box, and the whole thing afterward covered and shaded from the heat until the insect, completely fooled by the scheme, burst into song, believing that darkness had truly descended. At this instant the cover and shade were removed and the exposure made at once. After a number of failures, three splendid pictures were secured. These were afterward enlarged to the desired size.

Two animals that try the patience sorely are the Dragon Flies and Rove Beetles. Both are ferocious, preying creatures, but, like most wild things, will submit to captivity if properly looked out for. I obtained very good results in photographs by placing a Dragon Fly in my cabinet and feeding it smaller flies, while the Rove Beetles lived happily enough beneath decayed vegetables and darted out to capture the other insects that might be found feeding upon them.

Honey is of great use in attracting insects to a certain spot, while the addition of a little liquor to the broth will stupefy the more alert ones into complying with the photographer's wishes in a most satisfactory manner. In this way I have secured pictures of butterflies and wasps, the latter sometimes in quarrels and debauches.

In the deep jungles of South America, where the shade is very heavy, a great many species of solitary wasps build their delightful houses. Here in the dank twilight, below the myriad tangled branches and air roots, no camera, however perfect, could bring back the records that a naturalist must have. There is no light at all where many of these forest dwellers suspend their cradles, and it is only with difficulty that focussing is accomplished with a powerful searchlight. The photograph itself cannot be taken by the illumination of a flashlight, but by using large sheets of magnesium paper and burning them at the side of the camera, the sunlight may be artificially reproduced.

In such cases, the shutter is opened the minute the insect arrives at its nest, and as wasps usually rest for a few seconds after the flight, the flash sheet may be quickly touched off and the portrait made. In this



Fig. 78. A small bee photographed in the glass box. Much enlarged. A chance composition which is indeed pleasing. Note the lump of pollen on its leg.

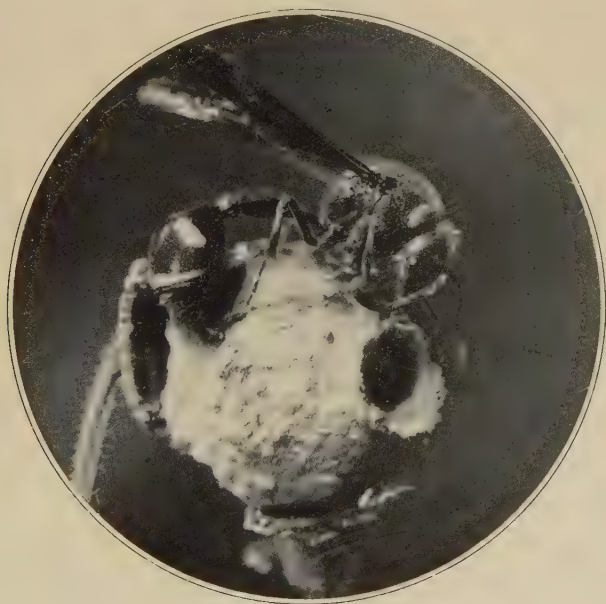


Fig. 79. The Potter-wasp, *Eumenes fraternus*, on her earthen jug which she uses for a nursery. Much enlarged. From a mounted specimen.



Fig. 80. A larval, or young beetle attacking a worm. This is a young Rove-beetle. They are very ferocious creatures in their world, and the old ones will often lie in wait for other insects, pouncing upon them and tearing them to bits much as a lion does its prey. They also are useful scavengers. Much enlarged.

way I have secured pictures of insects and even birds in caves and tunnels almost devoid of light. The flash sheets are held in a tin holder and ignited through a hole from the rear.

Every nature photographer knows that birds are easiest to approach and photograph at their nests, and so it is with wasps. In addition, they are quite like some birds in that they may be attracted by putting up nesting boxes for them. Small tubes of glass or wood afford the best nests for them, and as these may be conveniently placed in sunny spots, the owners may be easily photographed at home.

An important addition to the photographer's outfit is a large mirror. With this, sunlight may be thrown into all sorts of dark nooks and corners in which pictures could not otherwise be made. I once made pictures in a hayloft, where flash sheets would have been very dangerous, by reflecting the light to the proper spot with two mirrors. In another case, where Paper Wasps were to be pictured at home, the nest, which had been built in a bird-feeding station, was moved a few inches each day until it was twenty feet from its original position, and light could be reflected upon it.

Once in a great while one comes across a subject that is slow in motion and with which no difficulty will be experienced. Such are those insect sloths, the Thread-legged Bugs, most grotesque of our common insects. If you have seen the motion pictures taken in slow motion, you know exactly how the Thread-legged Bug moves. They are fascinating to watch and pure joy to the sorely tried insect photographer. They will keep quiet for hours at a time and make themselves at home in any box, if fed on small flies.

Occasionally it is desirable to picture the interior of an insect home, such as the burrow of a wasp or bee. It is impossible to excavate these tunnels without losing most of the details of the nest, and other methods must therefore be resorted to. I tried schemes without success, but finally procured a gasoline torch and a ladle of lead. This I melted and poured very carefully into the insect's burrow, thereby securing a perfect cast in metal, which was easily dug out of the earth. From this model I made a second model in wood, which was afterward coated with sand from the real burrow and photographed with excellent results.

Once when in British Guiana I had occasion to photograph the great metallic blue butterflies known as *Morphos*. The problem was to bring the big erratic insects to a desired spot. Once you capture one in a net, everything is over as far as calming it is concerned. You might just as well try to keep an animal quiet by poking it with a red-hot iron. It occurred to me that use might be made of their brilliant colouring, which is undoubtedly given to them to bring the sexes together. Accordingly I caught and killed one and placed it upon a leaf. In my hatband I placed the wings of another and then set up my camera and waited. Before very long, a flashing, crazy-flying individual appeared far down the trail. In answer to its flashes, I shook my head and the wings in my hatband and caused the butterfly upon the leaf to move also. The result was almost instantaneous. The living *Morpho* came directly to the lure. After this I collected a number of these beautiful butterflies by this simple trick.

Half the battle in insect photography is patience, and the other half is in accurately handling the lens and plates. It is often possible to manipulate a plate with chemicals to bring about desired results; thus, as sometimes happens, when it is impossible to keep an insect still long enough to expose a plate properly, an under-exposed one may be greatly intensified, and this intensification may be still further increased in the printing so that the final picture will be quite passable. I know my lens by heart, and in photographing with the enlarging lens always try to over-expose a little bit. Often I do not use the watch to time the exposure, but simply open the shutter and give the plate as much time as possible before the subject moves.

The diaphragm of the camera is of vast importance. This is marked in most cases 4, 8, 16, 32, 64, and 128. Now if you wish detail in a picture, you must stop down, or close the diaphragm, but every time you stop down to a higher number, which makes the hole through which the light rays travel just that much smaller, you must double the exposure. If your exposure at 8 was to be one half second, your exposure at 16 would be one second, and so on. Always remember this and always stop down as much as you can with such small subjects as insects. Another point of much importance to remember is that the light in fall and winter is much

weaker than in the summer when the sun is higher, and you must allow for these differences.

A book should be kept giving dates, exposures, and light conditions in full. You can always refer to this after you have made a hundred or so entries, and you will have a permanent and accurate exposure guide for your particular camera and locality.

I advise the use of Orthonon plates, as these are double coated and give better colour values. There is no better developer than Eastman's Special, and this may be used for either developing or printing. It gives rapid, blue-black negatives and is ideal for the travelling naturalist, combining as it does the whole developing outfit in one tube.

CHAPTER XIII

HOW TO STUDY AND PHOTOGRAPH ANTS

THERE is only one method of ant study that may be successfully followed if the real intimate home life of these insects is to be known. We must bring the colony into our study, where, at our leisure, and with all necessary apparatus at hand, we may take instant advantage of important happenings in the colony. To do this is quite simple by means of the glass formicary or ant hive. (Fig. 84.)

The type that I have used with greatest success consists of two sheets of glass, five by eight inches in size. These are used for the top and the bottom on the nest box. Several smaller pieces of glass are cut in strips one quarter of an inch in width, and these are fastened around the edges of one of the larger sheets of glass, with Major's cement. The strips go around the entire edges, except for a small space a quarter of an inch wide which is left open at one end. Fine sifted earth is now put into this little glass tray just level with the strips. When this has been done, more cement is spread upon the exposed surfaces of the strips, a small space is cleared in the centre of the earth, a colony of ants dumped in, and the other sheet of glass is quickly pressed down upon the cemented strips. This forms a shallow glass hive, transparent on both sides.

The edges of the hive must now be firmly bound with gummed paper and the entrance hole closed with it also, and the entire thing put away in a dark closet for a few days.

When the ants have settled down and collected their rudely shaken household goods together, the hive may be brought out and set upon an inverted glass bowl stood in the centre of a tray of water and the glass top of the hive covered with cardboard to keep it dark. The insects hate daylight in their nest if it is at all bright, but after a few weeks they become accustomed to subdued light and may be observed for long periods without disturbing them seriously. I have found it truly astounding to



Fig. 81. The Monarch Butterfly feeding on thistle nectar. A chance shot in the open. Much enlarged.



Fig. 82. A small predaceous fly photographed in the glass box. This is a good sample of the reward of patience. Much enlarged.



Fig. 83. A Robber Fly. Much enlarged.

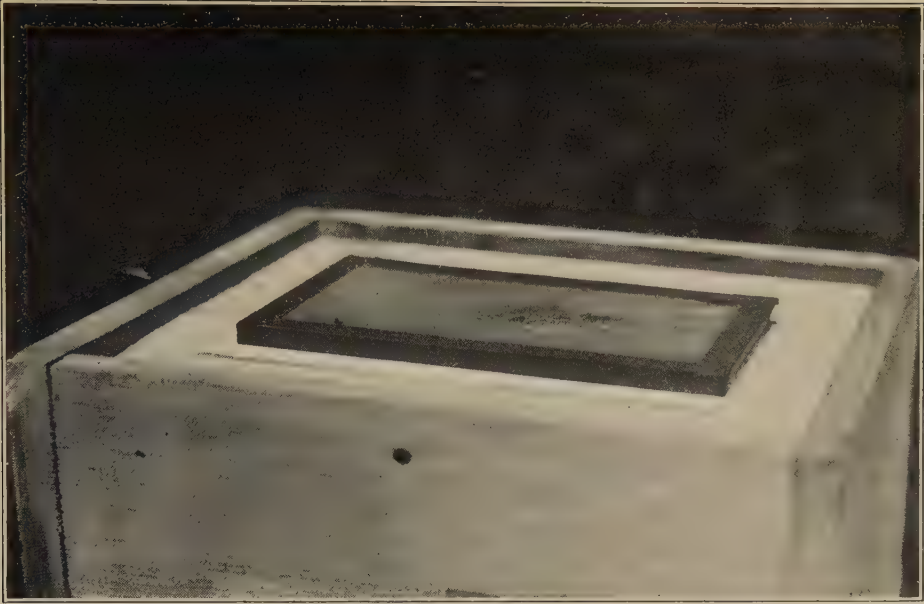


Fig. 84. The glass formicary or ant hive placed upon a box in the sun ready for making photographs. It is shown about one quarter life size.



Fig. 85. Carpenter Ants in the act of battling. An actual life photograph of staggering and weakened warriors and their victims. Ant battles involving entire colonies are not uncommon.

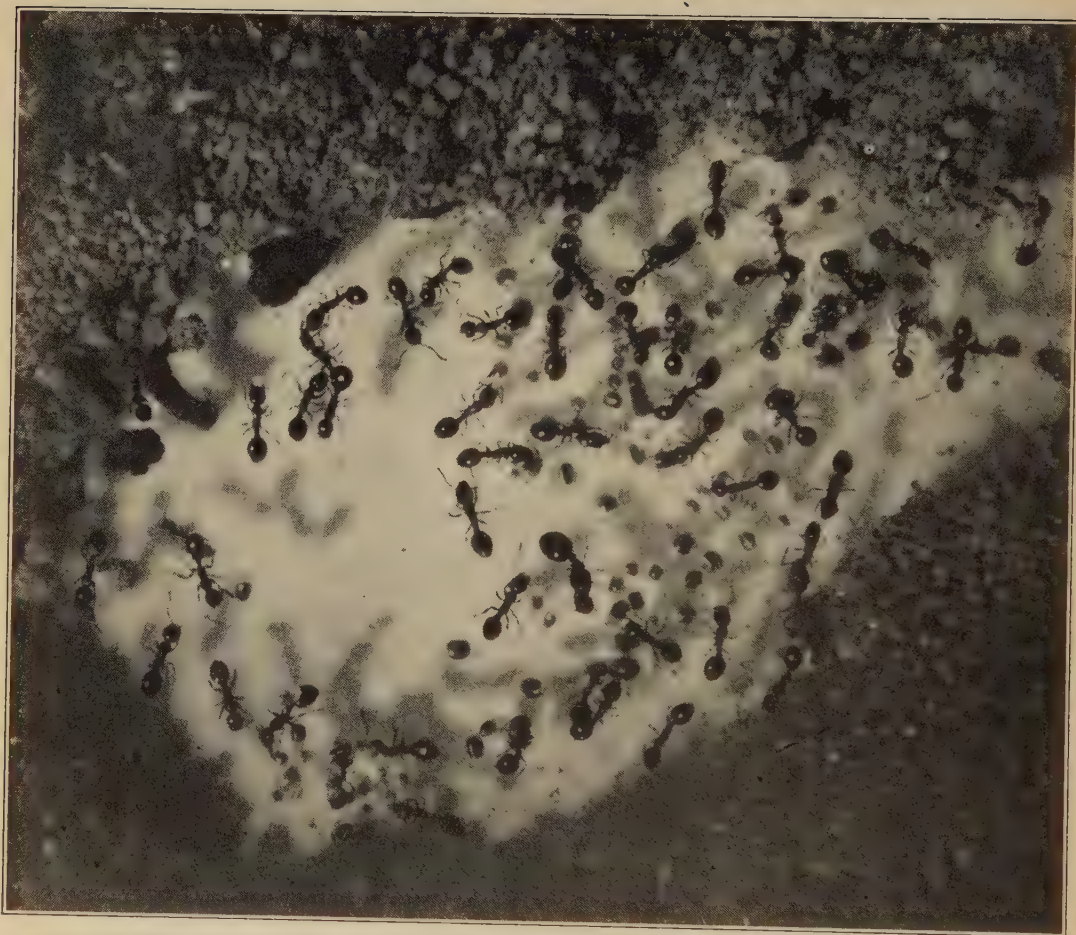


Fig. 86. The interior of an ant colony photographed by means of the glass formicary. The queen is the largest individual near the lower centre. Study this picture closely and see all that is going on.

observe these creatures by placing a binocular microscope, which erects the whole image, directly upon the top of the hive. With such an outfit, all the most intimate doings of the colony may be seen in great detail.

Greatest success will be achieved if small colonies of small ants are used. The best kind are found under stones, and it is absolutely essential that the queen be secured along with the wherewithal of the nest. It is a strange fact that the colony will cease work in a few days without the regal personage in their midst. She is the inspiration of all, and social activity cannot go on successfully without her.

The queen may be known by her much greater size, and her sole occupation is egg-laying. She is tenderly cared for by the worker members of the tribe and is often fed by them, probably upon the rarest morsels of the food secured. It is a good plan to insert a little water in the entrance every two days by means of a medicine dropper. This will prevent the earth from becoming too dry. A great deal of water should be avoided or the whole nest will fog up when placed in the sun for photographic purposes. I feed my colonies on whatever comes to hand—dead insects, bread, bits of meat, and any other thing that appeals to them. Feeding is necessary only for the first few weeks. After that I no longer keep the colony surrounded by a moat. I let it dry up and allow the ants to go wherever they please. They roam about the house and pick up a fine living without much effort.

Like all creatures, ants like treats and may be given a small amount of sugar or honey. Too much is bad, however, as they never know when to quit, and come home drunk and disorderly, causing much anguish to the sober ones at home. Another treat is to place a twig bearing a good colony of aphids or plant lice near the nest. This makes a great hit with all hands and gives the ants an added article of diet in the form of a sweet fluid that is obtained from the plant lice without injury to them.

In one of my formicaries, the ants made a storeroom close to the entrance, which they partly walled up with fragments of china from the chipped side of the tray that held the nest. Whenever I would give them a dead insect, they would saw it all up into cubes of meat and let it dry. Then they would carry all this stuff up to the storeroom, using only small amounts at a time.

The system with which things progress is very interesting to observe. For instance, as débris and refuse collect, the ants carry it to one side of the nest and pack it in back of fresh, clean particles of earth, which are brought from the edge of the nest on the other side. Thus the nest is always clean, and after some months the cavity where the nest was will be seen filled with refuse and dirt and the whole thing will have moved an inch from the original site. The eggs and very young ants are sometimes kept in a pile together, while the older larvæ are placed around the edges or in piles quite separate from the smaller ones. When a photograph of the colony is desired, I set my camera upon a tripod equipped with a device for tilting the whole thing, so that it is in a perpendicular position. A box is placed under the lens and the camera focussed upon a dummy ant hive, containing some dead ants. On the top of the box I have fastened a sheet of paper with an X marked in the centre, which gives a light background and a dark figure for centring purposes.

When everything is ready, with a plate-holder in the camera and with the slide withdrawn, I quickly put the real formicary in the place of the dummy, centring it by means of the X, which shows through the glass. The cover of the nest is then removed and the exposure made at the same instant.

The nest must be kept open but a short time and the exposure must be rapid, as ants will go wild in the sunlight, which heats up the nest almost at once. The entrance hole must of course be stopped during this operation. With a little care and practice, excellent ant pictures may be obtained in this way. (Fig. 86.)

In a normal ant hive containing one of these small colonies, about two months are required to bring a brood to maturity. About five days before the larvæ are to transform to pupæ, they become perfectly white or yellowish white, owing to complete excretion of all waste matter that was in their bodies. The old ants stop feeding them, and in some cases and species a silken cocoon is made by the larvæ. When these youngsters at length become full-fledged members of the ant world, they turn to and help in the rearing of the next brood.

The second brood among some of these smaller species that mature toward the latter part of the summer are usually males and queens,

and are possessed of wings. They leave the old nest in a marriage flight, pairing and soon losing their wings thereafter. The males die and the queens found new colonies by themselves.

It is wonderful to observe the old workers aiding the great marriage flight. Their aid sometimes consists of fairly kicking out the newly-weds, and all is great excitement, just as when a pompous wedding takes place at home. I might go on endlessly, but you should see these things for yourself by making a formicary of your own. If you start such a colony in the summer, it will be an unending source of amusement through the winter months.

CHAPTER XIV

PARASITISM, NATURAL CONTROLLER OF NUMBERS

AS WE are all aware, few creatures remain for very long immune from the ravages of parasites. From man down to the most insignificant organism on earth, all stand at the mercy of other living things that are ever on the alert to attack and slay their respective hosts. In man, disease and death are often due to parasites of the blood, against which science and medicine have already done a great deal in the way of elimination and control, but among the lower organisms, parasitism is the natural and necessary check upon overpopulation. Were it not for parasites here, we might soon be overrun by our most sanguinary enemies.

There is, perhaps, no class of living things among which the marvels of parasitic mechanism may be studied to such an advantage as among the insects. They are universally attacked because they menace life. Their ravages in the plant world would soon lay it waste, were it not for their parasites in the form of other insects, often of minute size, that are capable of destroying millions of the detrimental ones. Upon green plants all animal life depends, for it is only the plant that possesses the power of removing carbonic acid gas from the atmosphere, tearing the carbon away to build starch and sugar, and liberating the oxygen for animals to breathe and expel once more into the atmosphere as carbon dioxide.

Aphids, those tiny red or green or black plant lice that swarm upon plants in summer and reproduce in incredible numbers until the plants are dyed with their body hues, are parasitized by tiny hymenopterous insects. The parasite is born from an egg that has been deposited in the body of the host by the killer some time before. The young one is a grub that eats its living victim from within and finally burrows out through a neat circular hole in the brittle and spent body of the aphid. Millions of aphids are done away with in this manner, as the anchored, punctured bodies attest, wherever aphid colonies are found. (Fig. 87.)



Fig. 87. A group of Aphids that have been parasitized. Enlarged four times.



Fig. 88. Ichneumon parasite of the Cabbage Caterpillar. Greatly enlarged.



Fig. 89. A Cabbage Caterpillar with the larvæ of an Ichneumon parasite, burrowing out of its body to make their cocoons. Enlarged four times.



Fig. 90. Enlarged photograph of the cocoons made by an Ichneumon parasite of a caterpillar. Note the neatly cut caps and emerging parasite.

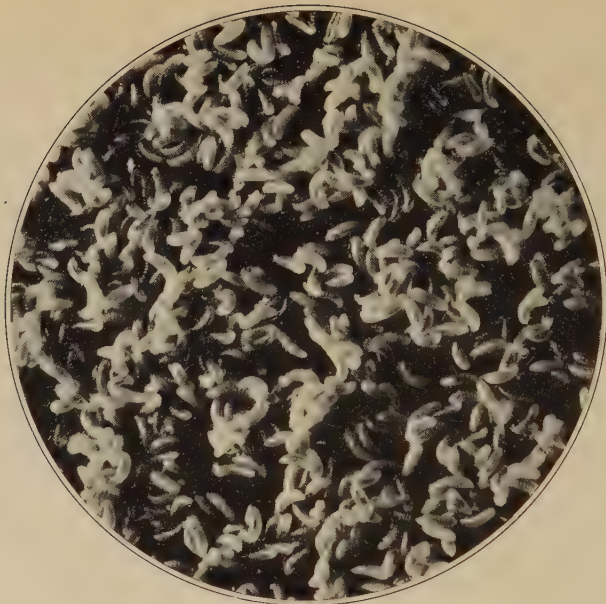


Fig. 91. Parasites in larval form, of *Sceliphron cementarium*. The imagoes issue as Ichneumon wasps about June 18th. The majority of the parasites are females. Much enlarged.



Fig. 92. Mature Ichneumon parasites that issued from a single larva of the Mud-wasp, *Sceliphron cementarium*. Much enlarged.

Caterpillars are sought out by slightly larger insects of the same order and their pupæ or chrysalids by still larger ones. Wasps and flies and other insects are affected in the same manner, so that almost all of them are held more or less in check.

In the case of the caterpillar, the mature parasite, a tiny, winged creature, seeks out its host, lights upon it with feet so dainty that it remains undisturbed and sinks its minute ovipositor into the living tissue. Here it deposits its eggs, sometimes in large numbers, and departs, perhaps to attack another insect near by. In a day or two these eggs hatch out, resulting in microscopic maggots which begin at once to eat their host. Later they may transform to pupæ within or without the body of the caterpillar, finally issuing as winged parasites some days later.

The caterpillar of the common Cabbage Butterfly is attacked by a parasite whose maggots burrow out of the host before it dies. Once out, they construct white silken cocoons upon the leaf beside the caterpillar, which is now spent but not dead. The significance of this is that a bird or other enemy of the caterpillar may now easily capture it. It is sluggish and sick from the parasitic attack and scarcely moves. If the parasites are to escape from the bird, or whatever the enemy of their host may be, they must get out while the going is good and make their cocoons in a safer environment. (Figs. 88, 89, and 90.)

A very minute Ichneumon parasite attacks the common wasp, *Sceliphron cementarium*. It works much in the same manner as those just described, but the entire metamorphosis or life history is carried out within the larval wasp as it lies in its cell. It is not uncommon that more than four hundred of these parasites issue from a single larva weighing considerably under half a gram. (Figs. 91 and 92.)

This is not the smallest insect parasite, however. In the tropical forests of British Guiana, I found many single eggs of butterflies and other insects, microscopic objects in themselves, that nevertheless contained their quota of still tinier parasites. One egg alone contained fifty parasites, and this egg measured one half of a millimetre in diameter!

Among these important little creatures nature makes sure of their fertility. From this egg just described, a male parasite issued first. He sat near the pin hole that he had drilled and watched the new-made door like

a cat. Through the microscope, William Beebe and the author watched him with intense excitement. Suddenly, a head appeared in the doorway and a female emerged into the outer world. Instantly the male clasped her, mated vigorously, and allowed her to escape. Now, one by one, the others issued from the egg, all females, and each in turn was fertilized by the waiting single male. Nature had attended to this business in her usual flawless manner. One male would suffice, and all his little harem winged their way into the world certain to destroy the eggs of countless noxious insects.

A classic case of parasitism is the work of *Megarhyssa*, the long-tailed Ichneumon that one sees occasionally upon the sides of dead and dying trees in the summer. These insects are five inches in length, including the tails, which are really a combined drilling and egg-laying apparatus. By some sense unknown to us they are able to locate the exact spot in the dead wood that is inhabited by the larva of the Tremex, or Horn-tail, a large wasp-like insect. With this slender hair-like drill, the Ichneumon actually punctures the solid wood, reaches the Tremex, and deposits an egg within its body, through another of its "tails." It is truly remarkable to see these insects in action, and once they have set their drill a human hand cannot pull it out of the tree without breaking it in two. Even the Tremex, in its dark burrow, behind an inch or two of stout wood, is not safe from the work of parasites. (Fig. 94.)

There is another common phase of this business of cannibalism called hyperparasitism. Here we find the host parasitized in the usual manner, but this parasite is also parasitized and in some cases the hyperparasite is also parasitized! (Fig. 95.)

In the egg cocoons of spiders this sometimes occurs, and I have often wondered how far this might be carried. Perhaps, as the saying goes, *ad infinitum*.

Sometimes two parasites will attack the same host, and in cases such as this Nature has looked out for them by decreeing that one shall be minute and the other large. Otherwise, if each were of considerable proportions, neither would be successful and the plan would perish. We may see, in Fig. 96, where two such parasites have issued from their host.

The two holes of widely different diameters attest the size of the destroyers.

Caterpillars that successfully reach full growth and burrow into the earth to transform to pupæ often unknowingly carry their destroyers with them. In other words, they dig their own graves and bury themselves. Below the surface, the gruesome business of parasitism goes on just the same as in the world above. Occasionally we turn up a caterpillar mummy bored full of holes which tells this interesting story. (Fig. 96.)

As I have said before, there is seldom much left of the host to tell the tale. This is also probably planned by Nature in her economy of things. For every body that is reduced, many other bodies are brought from its ashes, and these in the case of parasites are of a useful nature. The harmful insects give way to the more beneficial ones, and this is the essence of parasitism.

CHAPTER XV

FUNGOUS DISEASES THAT DESTROY INSECTS

IN THE Mississippi Valley there is a disease of insects known as the Chinch-bug cholera. It is known in other parts of the country also, but perhaps not so well as there. This is one of the diseases that benefit man, for it attacks only insects that are injurious to his crops. The disease is caused by a parasitic fungus known scientifically as *Sporotrichum globuliferum*, and its host is the dreaded destroyer of corn and wheat, the Chinch-bug.

It is of great interest and importance that this fungus may be cultivated artificially in the laboratory. It thrives on culture media of different kinds and may be sent out to farmers in badly infected districts. The method followed is to distribute the bodies of infected insects in the fields, either dead or alive. The sickness is then contracted by other individuals and the scourge soon spreads over the infected territory, lessening, if not exterminating, the pest altogether.

Many kinds of insects are subject to the attacks of fungi, but it appears to be a fact that they thrive only in moist weather. The Chinch-bug fungus is probably the only one that has been seriously experimented with and turned to the use of man, but there is no doubt at all that others might be brought under control and eventually become of great benefit.

Our common House Fly is subject to a fungous cholera, due to the attack of the species *Empusa muscæ*, which slays its victims in large numbers during the late summer. Swollen flies are often seen at this time of the year clinging to the walls of kitchens or other frequented places. About the dead or dying insect will be seen a ring of white mould, due to the spores of the plant which have been ejected at maturity. One fly catches it from another, often because the living flies light upon and taste the white killer of their brothers. Others catch the disease from spores in the air, and soon flies are dying all about us. (Fig. 97.)

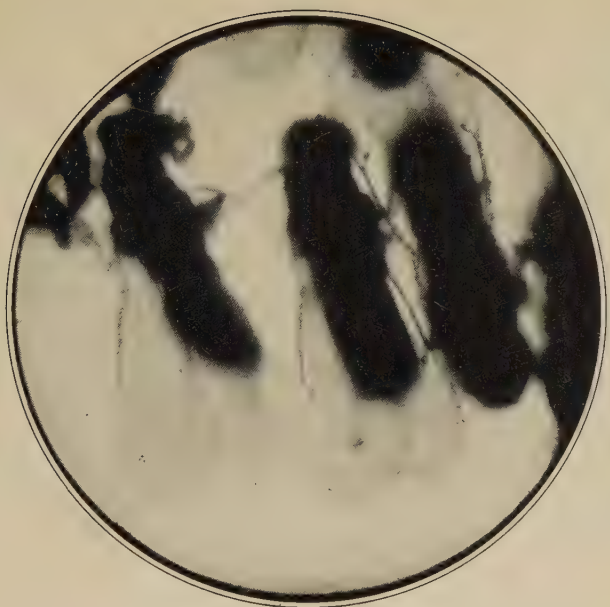


Fig. 93. Photomicrograph of parasitic Hymenopterous insects that issued from a larval wasp. Greatly magnified.

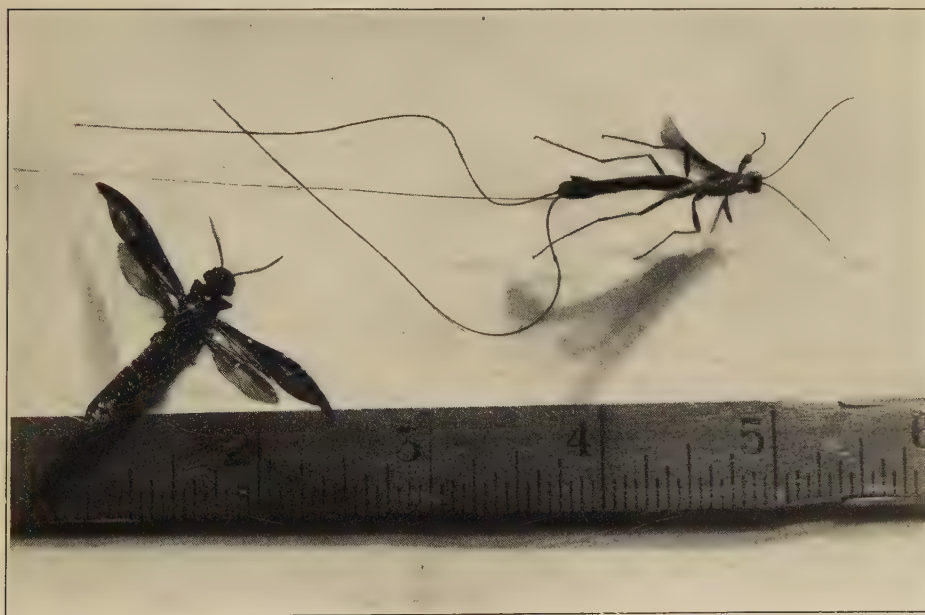


Fig. 94. Megarhyssa, the long-tailed Ichneumon parasite of the Tremex, another winged wasp-like insect. The Tremex is shown below. Life size.



Fig. 95. Hyperparasitism. The three galls shown in the picture are found as fleshy growths upon leaves. Within these growths of plant tissue the young gall insects live and feed, and the swellings are caused by the irritation of the plant tissue. In the first gall, which has been cut open, we see the larva of the rightful owner. The second gall has been parasitized, as shown by the numerous larvæ, by parasites that have eaten the young gall insect, while in the third gall, still another and smaller parasite has eaten the parasite that ate the original owner!

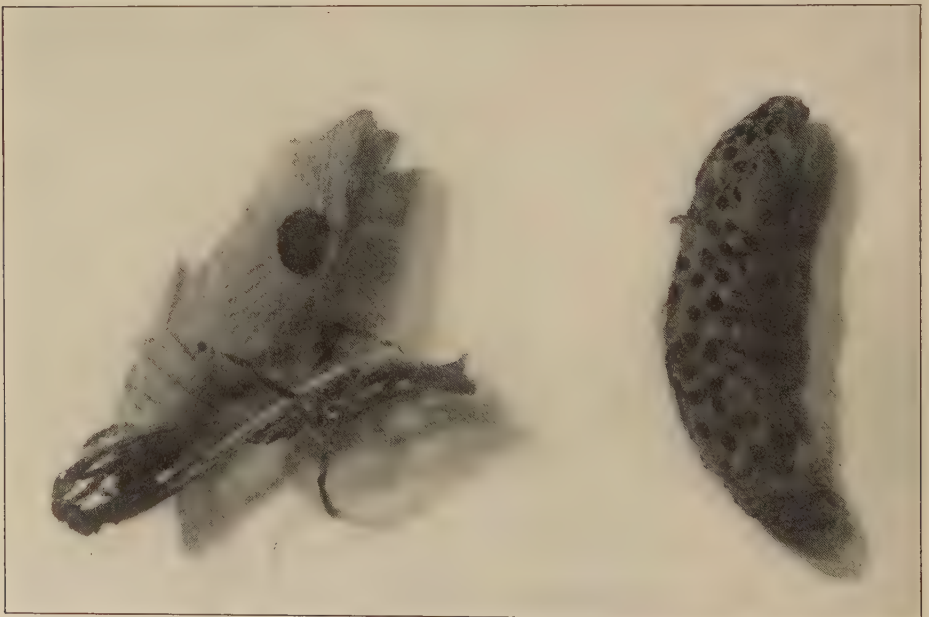


Fig. 96. The chrysalis of a butterfly that has been parasitized by two different-sized individuals, and a mummy caterpillar drilled full of holes by issuing parasites. Much enlarged. One of our most beneficial insects is an *Ichneumon* that attacks the Tent Caterpillar. It issues through a large round hole which it drills in the pupa of this species



Fig. 97. Two House Flies, *Musca domestica*, that have been attacked by a fungous disease called *Empusa musca*. The beetle at the left has been killed by a similar disease.



Fig. 98. A large black ant killed by a fungus that anchors it to a leaf and sends up these strange fruit streamers.

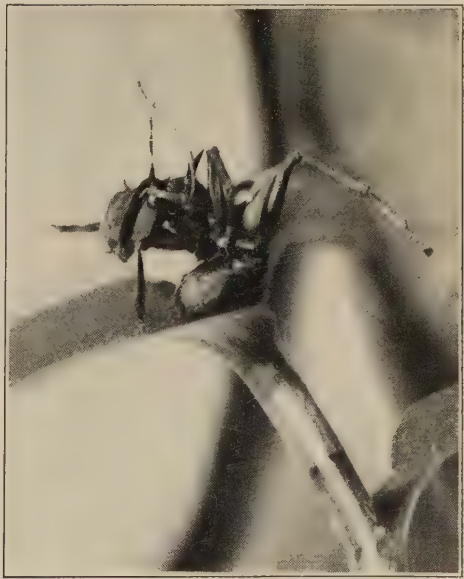


Fig. 99. Another ant, curled up in death with the fruit stalks of the killer growing triumphantly above.



Fig. 100. Wooden tablet tube used as a nest by *Odynerus unifaciatus*, split open to show cells and provisions and an egg in the upper cell. Greatly enlarged.

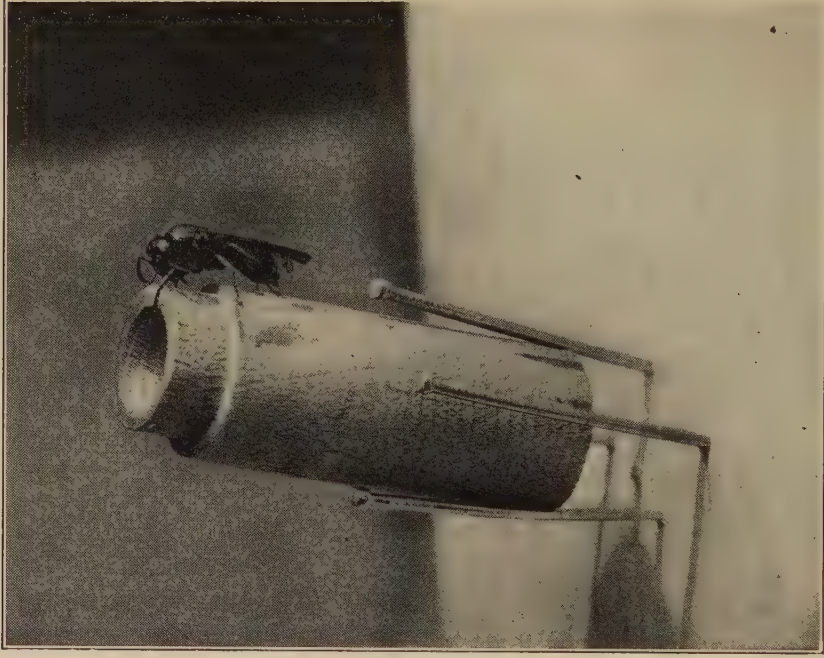


Fig. 101. The wasp on the window sill, upon her tablet-box nest. Wasps will come to nest boxes just as wrens and blue-birds will, if the proper kind are supplied. This wasp is *Odynerus unifaciatus*.

It should be possible to cultivate this fungus in the laboratory so that it might be liberated as spores, early in the year, and from time to time thereafter by turning loose infected flies. Here is a valuable piece of work for someone and an accomplishment that should not prove difficult.

In our American tropical forests and in most tropical countries these fungous diseases of insects are very common. The warm humid air is exactly suited to their growth, and one finds them sprouting on all kinds of insects.

Ants are quite generally afflicted, but in many cases it is possible that the plant attacks the insect after it is dead. Those species that attack the host while it is still alive are the only ones that would lend themselves to economic uses, and much careful observation would therefore be necessary before proceeding.

So common are these fungi in the tropics that an entire book has been devoted to them, and some of these weird plants are shown in the illustrations in this chapter. The portion of the plant that is visible from the exterior is simply the fruit of the organism. The body of the plant consists of very delicate, thread-like processes that gradually infest the entire abdomen and thorax of the victim, strangling it and firmly anchoring it to the surface of a leaf or other support. The fruit, in the form of a knobbed stalk, or many thread-like projections, at length pushes through the shell of the host and liberates its spores, which in turn infest other insects.

This is the procedure of fungi in general, and we often forget that even the common toadstools and mushrooms which grow above the ground are simply the fruits of the delicate thready plants which we seldom see.

The big black ant shown in the photograph was found in the forest of British Guiana, and was in a mummified condition owing to the completeness with which the plants had penetrated its victim. The body had soon dried up, leaving it as I found it. (Figs. 98 and 99.)

The final attack of the disease, the onslaught that slays the unfortunate sufferer, must come very rapidly and suddenly, for otherwise why should we find ants and beetles cemented to the centre of leaves that wave about in the slightest breeze? Fungi grow very rapidly anyway, and

probably, as the diseased creature stops to rest its aching limbs, the deadly threads break loose and set their net, from which the insect will never again escape alive.

One of our most destructive insect pests are the Plant Lice or Aphididæ. These bugs reproduce during the summer by giving birth to their young alive, and a normal mother may bear four or five a day. They suck the juices of plants and often cluster in countless numbers upon the leaves and stems. A full account of their lives is given in Chapter XXI.

They are attacked by many parasites, one of which is a fungus, and this little plant rids us of thousands of aphids during the summer. Properly controlled, it might become of very great importance, as the following preliminary experiment carried out by the author will attest.

Some of the infected aphids were taken from nasturtium plants and their bodies were used to inoculate sterilized test tubes of culture media made from meat infusion, peptone, and sodium chloride. These inoculated tubes were allowed to incubate at room temperature, and excellent growths were secured in some of them. A box was now prepared in which the temperature could be kept quite warm and the air humid by means of damp earth in the bottom. Very little ventilation was allowed within the box, within which the living aphids upon their food plants were placed, together with the fungous cultures removed from the tubes. A miniature electric fan was next arranged so that a current of air, but a very weak one, circulated over the fungi. The idea in this was to scatter the spores, as soon as they appeared, throughout the damp colonies.

In a short time the insects were affected in hundreds, and these were now placed, plants and all, among the rest of the pest-ridden nasturtiums, with the result that the whole aphid colony was much reduced.

Fighting insect enemies by means of fungi opens a big field to the experimenter with patience. We are likely, of course, to overestimate the importance of such tests, especially if attended with initial success, as the successful laboratory test may not necessarily work out in the field. I have no doubt, however, that persistence and thorough investigation of the many but little-known species might ultimately result in benefits far surpassing any that have already been realized.

CHAPTER XVI

THE WASP ON THE WINDOW SILL

FAR, far back, in the early days of the world, there lived a lowly thing that scientists have since named *Peripatus*. It was not a highly specialized or fortunate thing, for living, as it probably first did, upon an earth devoid of most enemies, it needed little protection. Besides this, it probably was distasteful anyway, for it has survived all those countless years and is found to-day in the jungles of America and Africa.

Peripatus possesses a long, cylindrical body with a pair of feelers at the head end and a pair of mandibles for chewing. Along its sides are rows of soft protrusions, or legs, if you like, each fitted with a pair of chitinous claws. This creature, half worm, half something else, is probably the ancestor of modern insects.

This creature and the primitive mollusks, a level land with little vegetation, and a great amount of ocean water are about all that one would have found in this particular stage of the earth's history, but the discovery of the ancestor of the insect is all we are after, so let us skip ahead over those many million years to the dawn of insect day and the laboratory window sill in the year 1916.

Upon the sill sits a wasp. Her face is bright yellow and her body black, hooped with rings of the same colour. She is a member of the most advanced and specialized order of modern insects. Possessed of a sting and poison sac, a set of powerful wings, six agile legs, armour, and a brainy way of reacting, she is at once a creature of distinction. Beside her is a neat cylindrical tube of wood, a tablet box such as pills are dispensed in, secured to the sill by slender nails and placed there for the sole purpose of attracting her ladyship. (Fig. 101.)

The tube has been chosen in preference to rougher natural holes wherein to rear her young. Just as wrens and bluebirds come to nest with the bird-lover, so the wasps come to my window ledge to rear their tiny families in contentment.

In a little while the wasp proceeds to her work. She enters the tube and crawls to the back of it, and there, upon the wooden ceiling, deposits a tiny yellow egg, fastened at one end, so that it dangles in midair and sways at the slightest vibration. The problem now before the wasp becomes serious, for within a very short time the egg will give up its wasp-let inmate, which must eat immediately upon issuance into the world, and, further, must be secured with plenty of reserve food to bring it to maturity, for solitary wasps such as this one do not feed their young from day to day.

In great haste, she ventures forth, after labour in the tube, in search of the tiny inchworms that constitute the fare of her offspring. She is always successful, so that in eighteen or twenty hours, just before the egg hatches, seven or eight fat larvæ have met their fate. (Fig. 100.) Paralyzed by the wasp's sting, but alive and fresh, they are sealed up with the egg behind a stout plug of mud, which is the universal insect mortar. At length the egg hatches and the young one consumes its meal. In five days the thing is done. The cell in which this creature finds itself is now empty of food and there is no way out. It cannot force its soft body through the wooden walls or the mortar plug of the chamber, so here it remains, as we shall see, for a very important reason.

At this point it will be well to examine the young wasp at close range. Many will be surprised to find it utterly unlike its parent. It has no feet, no wings, no sting, and no distinct parts to its body. Where is the armour of the wasp? The brilliant colour? The definite insect? All are missing, and we wonder why. The body of the youngster is softer than putty, its shape is rather cylindrical, tapering somewhat toward the head, and is composed of thirteen ring-like segments. Along its two sides are rows of soft protruding humps. It is gray and yellowish white and somewhat transparent.

As our first astonishment wears off and we begin to ponder the question of why this thing is so, our mind travels back and back once more over those countless years to *Peripatus*, the ancestor of insects. In our young wasp we see its worm-like body; along its sides the soft humps of ancestral legs; at its head the incurved or hooked mandibles; all characters of *Peripatus*, carried up through the ages, even to youth, at the apex of insect life!



Fig. 102. Photomicrograph. Part of the respiratory system of a larva of *Sceliphron cementarium*, in January before disintegration of the larval body has set in. The black areas are clusters of fat, and the pipes are the aerating tracheæ which lead to all parts of the insect body. Magnification 40.

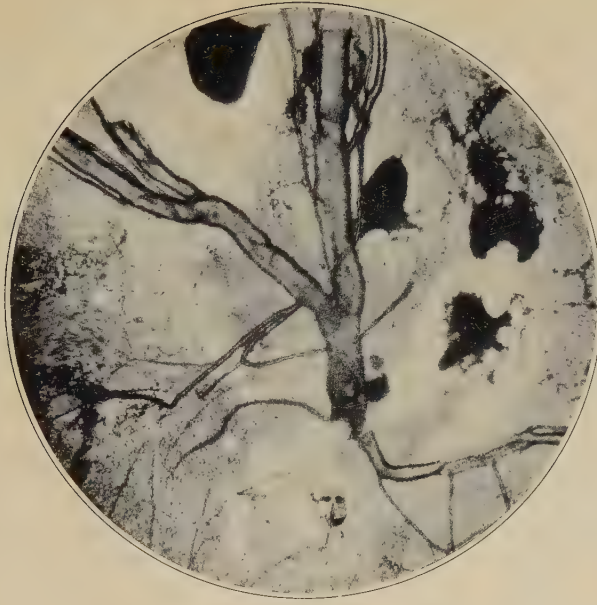


Fig. 103. Photomicrograph. Later state in the larva of *S. cementarium*, January 30th, showing fat cells in faint outline, filled with fat globules. At this stage disintegration of the larva has commenced. Magnification 40.

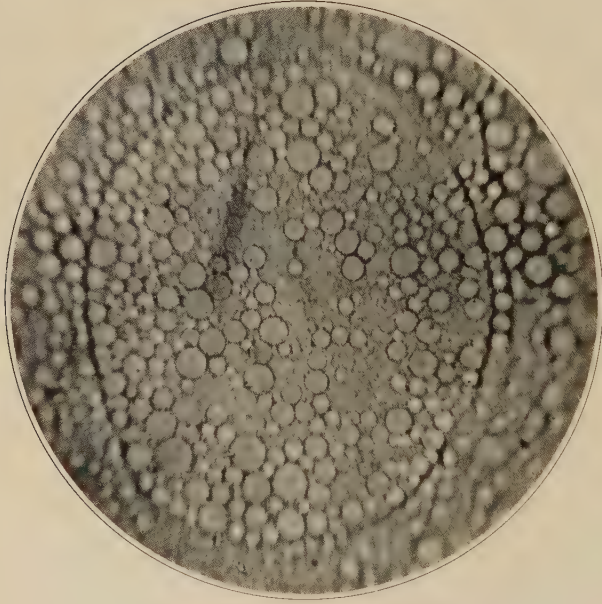


Fig. 104. Photomicrograph. A single fat cell, showing its contents consisting of numerous drops of fat. Fat cells, of which there are great numbers in the larval body of the wasp, doubtless serve as nutrients for the processes of metamorphosis. There is also a relation between the fat and the blood system, as the former is found floating freely in the blood plasma or fluid. The corpuscles of insect blood are too minute to be shown in this photograph. Insect blood is concerned chiefly with the nutrition of the creature and not with aerating the tissues as in higher animals. Magnification 380.

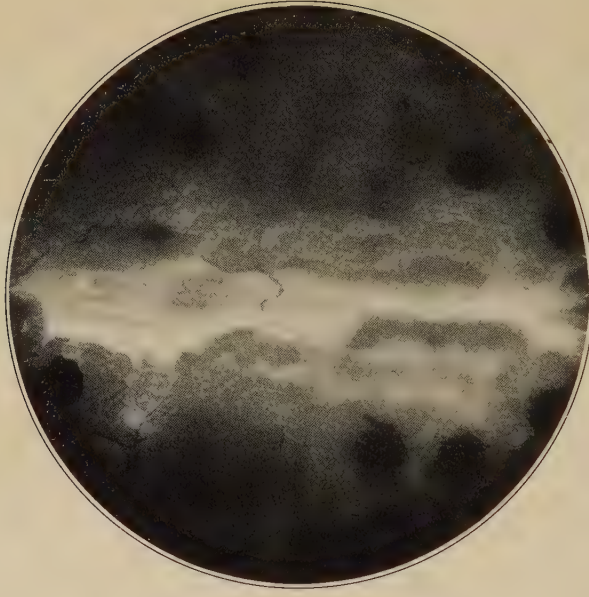


Fig. 105. Photomicrograph. An X-ray photograph looking through a living larval wasp during the reconstruction of the raw material into a pupa. Note the groups of cells arranging themselves, and the nerve running through the centre of the whole thing. Magnification 40.

In a few days our wasplet will spin a flimsy cocoon of silken threads, and a few weeks later issue as a highly specialized wasp like its parent, yet to-day it is nothing better than the creature from which it evolved, *Peripatus*, the lowly thing that crawls upon the jungle floors. How may such a change be wrought? In fourteen days the process of millions of years must be started and finished, for to-day we see the ancestral form and to-morrow the finished wasp! To the very last, the ancient characters persist. How is the gap from ancestral to a modern form so easily bridged?

In the insect world we find conditions unlike those among the higher animals. The young horse, for instance, arrives in the world exactly like its parent except for minor details. The bird hatches from its egg unlike its mother, but soon grows to resemble it by the addition of food to its stomach, but what of the wasp? It is born as an egg, no more like an insect than a seed of a plant. It hatches from the egg as a grub, and all the eating that it can do results in nought but a larger grub, so the poor creature simply gives up the job, spins a cocoon in its cell, and waits patiently for whatever life has in store for it. Here enter two of nature's most industrious forces.

Summoned to the rescue of the helpless grub, they enter it hand in hand and forthwith set to work. Let me introduce them: Number One: *Histolysis*. Number Two: *Histogenesis*. (Figs. 102 and 103.)

Number One begins the job. Within the outer skin of the motionless grub it sets its labourers to work. They are wreckers pure and simple, and without mercy they tear down the whole interior structure of the larval house. Ruthlessly they kick everything to pieces, except, as in any house under complete alteration, the vitals of the structure. The tissues of the grub are completely disintegrated, and should we puncture the wall of the poor creature, that which was so lately solid muscle would run out in yellow liquid, studded with globules of useless fat. Such is the utter havoc wrought by Number One. Now what is to be done? It would appear that matters were worse than ever, and so they would be were it not for Number Two. (Figs. 104 and 105.)

The labourers of Number One are now called off, and those employed by Number Two commence. These are the reconstructors. With plenty

of raw material to work with, they set about to make a wasp. Trained in the art of building nature's finished products, and knowing nothing of the experimental past, they soon bring order out of chaos. The structure grows apace. The body and thorax and head are shaped and built. The legs are moulded and the organs of flight, reproduction, and digestion are created by these skilled workers who remake everything, every part of the new creature, from the materials left by the wreckers.

All this takes place within the larval skin. For a time nothing is visible from without, there is no sign of the radical changes going on behind those walls of delicate skin. Then, all at once, a depression is noticeable in the centre of the grub. It remains for a day or so unchanged, then the skin splits open and, like a blossom unfolding, the perfect wasp appears, reborn and made from herself!

The workers now paint this creature from within. With bright pigments they cover her transparent form and then depart. In a day or so the wasp gains strength, leaves her cell by cutting her way out through the door of mortar, and flies off to repeat the work of her parents.

We see, then, that evolution functions as any industry whose work is complicated. Its finished products appear only after long years of experiment, but once they have been perfected they are easily and quickly duplicated thereafter. So our wasp, the result of some millions of years of development before the first one was produced in the factories of nature, is now built and thrown into the world in a month.

As we watch the process, we see some of the stages through which the original one probably passed, but the experimental period now being over, Nature has found that with a few caterpillars and a larval skin as raw material for Histolysis and Histogenesis to work with, a modern wasp is indeed a simple thing.

And so with all the intermediate stages, once so carefully travelled, between Peripatus, the ancestor, and Odynerus, this modern wasp, discarded, the great gap between grub and imago is bridged in a fortnight!

Histolysis and Histogenesis are the skilled workers. The inchworms correspond to the ore, the grub to the heat of steel, and the wasp on the window sill is the finished product.

CHAPTER XVII

THE HUMAN SIDE OF ANTS

OF ALL the orders of insects, that one known scientifically as the Hymenoptera, which includes the ants, bees, wasps, and similar insects, is doubtless of greatest interest to man. The creatures that fall into this order are most highly organized, and while some few lower creatures may simulate their social life, probably no other living insects have reached such perfection in community life and division of labour as have the ants. Their ability to live successfully in great cities, under a single ruler or queen, in a state of perfect organization and contentment, has long caused man to delight in studying their ways, and I now wish to add my drop to the bucket of ant lore in the form of some first-hand photographs of their wonderful doings, which show, in a remarkable way, the very human side of these little insects.

As in our own big world, so in the smaller one of ants, the meat-packer is of primary importance in the ant city. In the tropics, especially, ant colonies are much more ferocious and bloodthirsty than in the north, and I have seen them completely strip a carcass of its flesh in an hour. These bits of flesh removed by the individual ants are quickly dried in the warm atmosphere and carried to the nests, where they are packed away for future use.

The nurseries of ant colonies are of great interest. These may be deep in the ground or in the black recesses of a great hollow tree. They are also frequently found beneath a flattened stone which is thin enough to become gently warmed in the sun. Under such stones, the baby ants, which at first resemble tiny maggots, are tenderly fed by the old ones upon especially prepared food, while those in a later stage of development may be warmed in the nursery during the daytime. Close inspection of an ant nursery will reveal all the tender care that one sees a human nurse or mother lavish upon her charges. (Fig. 107.)

One of the most human traits of ants is fighting. Their battles are very serious affairs often involving hundreds of warriors that fight until one or the other is torn to pieces.

Our big, black Carpenter Ant, with which most of us have come in contact, is particularly given to battling, and the place where such a battle has raged will be strewn with heads, legs, and broken bodies and dozens of living but badly wounded individuals. When one of these insects takes hold, it never lets go unless its head is torn from its body. There is little difference between the hand-to-hand methods of ant and man, as far as plain butchery is concerned. War seems to be the inevitable result of community life. (Fig. 85.)

Ants pillage their brothers' cities after a successful battle just as men do. They rob the vanquished of their hard-earned food stores and take prisoners which afterward become slaves.

For the purpose of war, a special caste known as the soldier or warrior ant has been developed by Nature. These individuals possess greatly enlarged heads and mandibles. In South America, the warriors in the tribes of the well-known Army Ants are indeed formidable antagonists, as the author can attest from several painful experiences in their midst. (Fig. 108.)

Perhaps the most remarkable instinct of all which we find among insects is the universal habit among ants of cultivating and tending their "cows." (Fig. 109.) Ant "cattle" are small insects known as plant lice (see Chapter XXI), or Green Fly, as the gardener calls them. These insects breed very rapidly and swarm upon the stems of leaves and plants. They feed upon the plant's sap, which is drawn into their bodies through their sucking beaks. Now at some time in the remote past, an ant or ants stumbled upon a herd of these helpless sucking creatures. In so doing, they discovered that when bumped into or touched, plant lice exude glistening droplets of a sweet fluid from two tiny tubes at the ends of their bodies. This the ants lapped up eagerly because of its saccharine nature, and in this act the seed of a habit became planted that has since gone around the world and is now the universal privilege of ants.

The tender care bestowed upon these "cattle" by ants is entirely because of this honey supply. So elaborate have the habits connected with



Fig. 106. Carpenter Ants resting upside down. Ants often rest for long periods in the most curious positions. Somewhat enlarged.

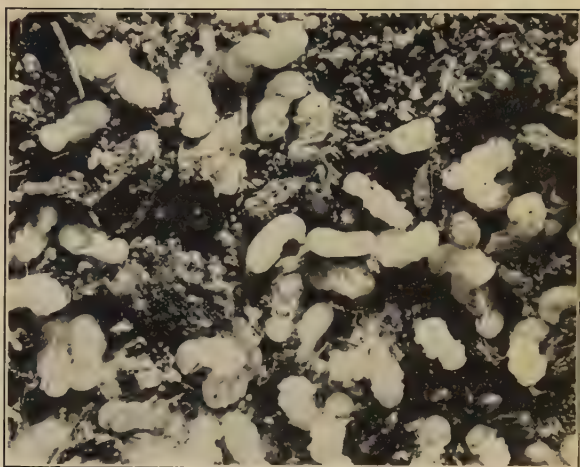


Fig. 107. Young ants in a nursery. The ones without eyes are larvæ. The others are pupæ. Enlarged twice.



Fig. 108. A warrior Army Ant, showing its huge mandibles. Greatly enlarged. These ants dwell in tropical forests.



Fig. 109. An ant tending its "cattle." Much enlarged.

cattle-tending become that a book might be devoted to this single subject. In some cases houses of paper or wood-pulp are constructed over the herds, barns actually, which are guarded by soldier ants that rush out with open jaws at the first sign of an intruder. Most interesting of all is the fact that in the North, the ants carry their herds under ground in winter, and place them upon roots beyond the danger of frosts, thus securing a supply of sweets through the winter.

There are highwaymen in antdom also. We humans of the big cities are not the only sufferers from the ravages of the bandit and criminal.

Let us turn back to the Army Ant of South America once more, for here we have the most perfect organization, I believe, in the insect world. We see them advancing through the great forest in a stream, perhaps six inches in width. Like a huge, well-drilled army, they advance twenty or more abreast. There are countless thousands of them, and the living, snake-like band moves steadily from morning until night. Millions of ants pass by like the veterans of a world war in review.

Look closely at the uneven places in their path, where perhaps a stone or fallen branch must be crossed. Do the first ants surmount the obstacle without a thought for those that follow? No, indeed; here is the spirit of altruism in the army also. The first to reach the obstacle throw their living bodies into the uneven space. Dozens follow the leader until the roughness is ironed out with ants, and the rest of the army trudges over a smooth path made of their suffering brothers!

To-day the command is to march, not to attack, and from wherever that mysterious command emanates, it is supreme, and not an individual dares to disobey. To-morrow the command may be to attack and, if so, woe be to anything in the path of these pitiless Army Ants. They surge through the forest, tearing their prey to shreds. By sheer weight of numbers they down creatures a hundred times their size. Mounting tree trunks and foliage, they send living showers of frightened insects down to the butchers below. Thus they hunt until, laden with spoils, the army returns to its temporary nest.

Sometimes the house of man stands in the way of the attacking army and, as terrible as the results might be, should man remain within, while the army passes, such visitations are really a blessing at times,

for the Army Ants care little for the larder. They are after their natural prey of spiders, roaches, and perhaps bats and mice, if they are lucky. These are unwelcome dwellers with man, and the Army Ants will rid his house of them, in a few hours, more successfully than he could himself.

When the Army Ants arrive, one must simply step out. Should the visitation occur in the night or during a storm, that is no concern of the army. Now, as ever, they are under a mysterious supreme command, and no ant dares to disobey.

What can be the form of communication that runs instantly through a million individuals? Here is something that outstrips our radio, but I should not be at all surprised if the two forms of communication were fundamentally the same.

CHAPTER XVIII

THE LIFE AND HABITS OF THE BLUE AND YELLOW DAUBER

Sceliphron cementarium

THERE will be many, no doubt, who, being unacquainted with the wonders of the wasp's daily life, will find it difficult to believe the facts set forth in this chapter. I do not think the story will bore even the initiated, for this little insect has indeed much to tell us. The story of its life and the strange stages through which it is hurled into maturity should be known to every nature lover. There are a great many species of wasps whose lives are as interesting as this one's. They only await the patient investigator.

Most of our wasps are solitary species. That is to say, they live by themselves throughout their lives, save for that brief moment which constitutes insect courtship and marriage. After this time the lady wasp has nothing more to do with her mate. Once pregnant, she sets about to build the house in which to rear her progeny. The male will have none of this. He flies gaily away and his cares are ended. Unlike the social species—hornets, yellow jackets, and the like—which live like humans in vast and irritable communities, the solitary species live peacefully by themselves, going about their own business and bothering no one.

Our wasp is one of these solitary insects. In June, the first ones of the year may be seen flitting among the flowers or sunning themselves upon flat stones which have become gently heated, but our real acquaintance with *cementarium*, who is at once a creature of distinction, commences somewhat later, when nest-building is in full swing.

We see her at the edge of a puddle or perhaps at the bank of a trickling brook—anywhere, in fact, where ready-made pliable mortar is to be had. There may be a dozen of these trim blue-and-yellow masons at their work. All look alike yet each is gathering its ball of mud for a house in a different quarter, which we know by watching each burdened insect flying

off in a different direction. Let us follow one that wings her way to a near-by shed and observe the building which is in progress. (Fig. 110.)

As we enter the doorway of the weathered building we hear the insect singing at her job. A high-pitched squeaking, produced by rubbing the wings together, constitutes the "voice" and leads to the discovery of the nesting site upon a cross-beam near the roof of the shed. Many wasps sing thus at their labour. Just as we humans whistle or sing when engaged in congenial labours, so these smaller folk of our world vent their good will toward all with the only "voice" which they possess.

The wasp upon the beam has just arrived with her ball of mud fresh from the puddle near by. We see her place it upon the surface of the beam and flatten it out into a pie with her head and mandibles. Satisfied with the job, she returns to the source of supply, gathers up another load, and flies back to the beam. Over and over this action is repeated until at length the insect has constructed a flat foundation upon which the cells of the nest proper may be safely built.

A finished nest may consist of a single cell or as many as twenty-five, according to what fate has in store for the builder; but each cell is completed separately, filled with food, upon which a single egg is laid, and then sealed up with mud before the second cell is started. When the foundation for the nest has been completed, the wasp continues gathering her mud pills and carrying them to the nesting beam, where with great care and much squeaking she fashions them into a series of overlapping concentric rings, fifteen in number, and thus a neat earthen cell is produced eighteen millimeters long by eleven wide, with a circular entrance at one end six millimetres in diameter. (Fig. 111.)

After the cell has dried for a time, the parent wasp commences the labour of provisioning it, and here, for a time, our gentle insect becomes fiercely predacious. The great majority of solitary wasps provision their nests with living creatures, other insects, as a rule, which have been paralyzed by the captor's sting. Our wasp searches out spiders, however, among the grass and flowers, and swoops upon them like a hawk. In an instant she lays them quivering and helpless with a double drive of her sting, and carries them unprotesting to her nest.

Spiders are peculiarly adapted to her purpose. Their nerve centres lie



Fig. 110. The common Blue and Yellow Dauber, *Sceliphron cementarium* upon her nest, resting. This is the abundant wasp of summer that builds her nest in the attic or upon the rafters of barns and porches. Three times life size.



Fig. 111. Front and side view of cells of the above wasp in unfinished nests. Note the concentric layers of mud in the construction. About twice life size.



Fig. 112. An opened nest of a Mud-wasp showing an empty cell and a cell crammed with spiders, one of which bears the white egg of the wasp. Greatly enlarged.

concentrated in two vulnerable spots, one on either side of the œsophagus in the cephalothorax, or forward division of the spider. A single drive from the wasp's poisoned sting from above and another from below reach these vital parts of the spider, instantly paralyzing its legs and all appendages which it was capable of moving. Only the respiratory system remains to function and keep the paralyzed victim alive for the young wasp to gorge upon. Helpless, but as living flesh, it is carried to the nest as provender for a new generation.

Arrived at the cell with its paralyzed victim, the wasp packs it snugly into the far end of the earthen tube, deposits a tiny, elongated, glistening yellow egg upon the spider's abdomen, then after a short inspection of the cell, makes off in search of further provisions. (Fig. 112.) The cell is thus packed full of victims, varying greatly in number, according to their bulk and the period of the nesting season. I have opened cells containing but seven large spiders and others that were packed with thirty or more tiny ones. A day or a day and a half are given over to the storing of the cell, after which it is carefully sealed up with mud, abandoned, and a new one started beside it.

It is interesting and important that the actual number of spiders preyed upon by this wasp is limited to eleven species, and this is true in separated localities. In other words, different individuals of the insect in question select the identical species of spiders for provender at different localities, these varying in their relative numbers with the advancement of the season. This is clearly illustrated in the chart (Fig. 113), which shows that *Phiddipus multiformis*, a dark-coloured jumping spider of stocky build, *Argiope riparia*, the common Garden Spider, and two common Epeirods are the chief victims of the wasp up until late July, when these four species are mostly eliminated from the cells, and in their place we find great numbers of *Misumena aleatoria*, the little yellow, crab-like species, and especially *Argiope transversa*, the Banded Garden Spider. These last two species together comprise 64 per cent. of all the spiders used by this wasp, as will be seen from the same chart. The other spider species shown in the diagram are only rarely and probably accidentally used and are of little importance. The six species of importance are illustrated in Figs. 114, 115, and 116.

CELL NUMBER	DATE	PERCENTAGE OF SPIDERS IN ALL CELLS	ARGIOPE TRANSVERSA	MISUMENA ALBERTA	PHIDDIPIUS MULTIFORMIS	ARGIOPE RIPARIA	EPHRA THYVITATA	EPHRA THYVITATA	EPHRA THYVITATA	TIBELLUS DUTONII	EPHRA SCLOPETARIA	XYSICUS LINEATUS	XYSICUS THICATATUS	NO. OF SPIDERS IN CELL	NUMBER OF SPECIES
1	7/6						7	4		1				12	3
2	7/6				6									7	2
3	7/6						6	4						12	3
4	7/6				5									9	2
5	7/6				1	10	4	1						16	4
6	7/7				1	12	4	1		1				19	5
7	7/7				12									13	2
8	7/8					4	2	4						10	3
9	7/8				8									9	2
10	7/8				8		1							9	2
11	7/8				7	2	6	1				1		16	5
12	7/10				6	1	8	3						18	4
13	7/15				1		11	1						13	4
14	7/19		1			10	1	1						13	4
15	7/19				8	1	3	1						18	4
16	7/20				9		1							10	2
17	7/20				6									6	1
18	7/20					6	1							7	1
19	7/21				15									15	1
20	7/21		7		4		3	2						16	4
21	7/21				1	11								12	2
22	7/22					6	1							7	2
23	7/23		7	1	6	1								15	4
24	7/23		1	3	2	4								10	4
25	7/23		3	1	4									8	3
26	7/24		1	5	2		2	2						12	5
27	7/24				13		1	2	3					19	4
28	7/25		14	3										17	2
29	7/25		3	7			3							20	4
30	7/25		3	11										14	3
31	7/25		3	19	1									23	5
32	7/27		1			3	1							13	3
33	7/27		6	19			4							29	3
34	7/27		1	21										22	2
35	7/27		16				3							19	2
36	7/27		25				1							26	2
37	7/27		18				1							29	2
38	7/27		22				1	1						23	3
39	7/28		2	7			1			1				11	4
40	7/28		14	2		1	2					1		30	6
41	7/28		8	2	3					1				14	4
42	7/30		2	22		1								25	3
43	8/2		17			9		5		1				32	4
44	8/2		24											24	1
45	8/2		25											28	1
46	8/2		25											28	1
47	8/2		25			1								26	2
48	8/2		10	7										17	2
49	8/2		20											20	1
50	8/2		36			1								37	2
51	8/3		20			1		2						23	3
52	8/3		12				1	1						14	3
53	8/3		15			1	2	2						20	4
54	8/4		16			1	1	1						19	4
55	8/6		16			2		2	1					21	4
56	8/6		12				1	1						14	3
57	8/7		23											25	1
58	8/10		6											10	4
59	8/15		27			3	1							27	1
60	8/15		10											10	1
61	8/16		15											16	1
62	8/15		15					2						17	1
63	8/15		20											20	1
64	8/15		14											14	1
65	8/23		22											22	1
66	8/25		16											16	1
67	8/25		10											10	1
Totals		44.551	442	804	117	100	74	48	5	3	2	1	1	1037	
AVERAGE NUMBER OF SPIDERS PER CELL															15+

Fig. 113. The detailed contents of 67 cells of the wasp, *Sceliphron cementarium*

Let us go back to the wasp's egg sealed within the provisioned cell. In three days the egg gives birth to a tiny yellowish maggot. Its body consists of thirteen concentric segments and pin-like head. It possesses no legs or other appendages suitable for locomotion, and progresses, if need be, by means of muscles which it expands and contracts alternately. This is the young wasp and is called the larva. Its first concern is to fasten its baby mouth to the fat spider upon which its provident mother placed it as an egg. Slowly, at first, it draws the nourishment into its own body and forthwith begins to grow. The youngster is a weakling, undefended and helpless against the slightest odds, yet it feeds on living spider flesh and blood, quite safe from harm. The meat keeps fresh and sweet, there is nothing fetid within the cell, and thus we understand the reason why the spiders are only paralyzed rather than killed outright by the parent wasp.

From five to eight days, according to the bulk of the provisions, the youngster feeds, never once stopping to rest, never excreting anything that it has digested. At birth it measures but three milli-

metres in length, but when the feast is over it is nearly six times that size. During the first day it makes but little growth, but thereafter increases rapidly from day to day.

When the young wasp has finished its repast, there remains very little of the feast uneaten. Usually the cell is cleared of every vestige of the paralyzed spiders, but occasionally a few fragments of the creatures remain. Bits of legs, hairs, or perhaps a dried and shrivelled body are all that the grub leaves in the wake of its orgy.

With many days of uninterrupted gorging behind it, and its cell quite emptied of food, the larva sets about to spin its cocoon. From its strange mouth flows a liquid silk which hardens in contact with the air. This it fastens at various points about the cell walls, and by drawing back from each point of contact the silken threads are drawn from its mouth. In all directions the larva throws these lines about itself until, at length, it rests in a flimsy cocoon supported in the centre of the cell. When this has been done, a second and much more substantial cocoon is constructed within the first. When completed it resembles a tiny torpedo. It is spun of silken thread like the first one, and then moistened with a sticky fluid which amalgamates with the silk and later hardens it, so that its inner cocoon turns brittle and reddish brown very much like the skin about the kernel of a peanut.

Two full days are required for the construction of the cocoon. The lower end of it is left open until the spinning is over, then, in one solid mass, the larva excretes the waste from its week of feasting. This serves as a plug to the open end of the torpedo. It becomes very hard and dry in a short time, and thus the insect rids itself of this waste and effectively seals its cocoon at the same time.

Safely inside, the youngster now passes into a deep coma in which it remains throughout the fall and winter. On the outside there is no sign of change, yet within the creature's skin a mighty one is taking place, a change which is to transform this maggot, this sexless, helpless, stupid ancestral form of an insect into one of the most highly organized creatures of its race. The process is known as pupation, and the form of the young wasp which results from it is called the pupa.

During the radical changes which the process brings about, the larva's

skin might be compared with the roof and four walls of a house or factory, the interior of which being out of date must be brought up to a modern standard. The four walls and the roof are left more or less in the same shape and condition. Likewise some of the building's "innards" may be left intact, but everything else, from garret to basement, is torn down or altered. Practically all of the old material goes back into the new design; it is simply recut, planed, puttied, and painted, and then put into a niche in the new design, that the old building with its antiquated processes may be made a thing quite up to date.

Within the larva of our wasp, its tissues break down and become disintegrated. Then gradually they are remade and returned, each to take up its new position in the new creature. All seems like hopeless chaos within, and what was recently our robust and ravenous maggot becomes, to the naked eye, a motionless yellow bottle filled with a watery fluid studded with white globules of fat.

As time goes on, however, the new creature takes definite form. Hidden from our eyes by that same old birthday suit made up of thirteen concentric rings of pudgy flesh these extensive alterations we are unaware of until, perhaps, the first or second week in May, some ten or eleven months after the larva spun its cocoon of silken threads.

At this time a shrinking in the centre of the larva and a decided change in the form of its head give us a hint of what has been taking place within, during the long months of its apparent sleep. One sees distinctly where the final insect's thorax will be divided from its abdomen. It is an intermediate stage between the larva and the pupa which we are witnessing. In this form it remains for two weeks or more, when the actual transformation to the pupa takes place.

The transformation is like the unfolding of a flower from its bud. From out the skin of the nondescript intermediate form the pupa bursts forth. It is sexed and nearly a perfect wasp in every way, but very tender and the colour of sugared honey. Its legs and feelers are almost transparent, and its wings are but two thick pads, one on either side of the creature's thorax. In the pupal state it lies motionless once more for nearly a month. During this period it receives its pigmentation, which appears first in the eyes. They turn reddish yellow, then purple, and, finally, black be-



Fig. 114. *Argiope transversa*, the Banded Garden Spider, most popular prey of the wasp *S. cementarium*. 44.55 per cent. of the spiders used as provisions by this wasp are of this species.



Fig. 115. More than 9.64 per cent. of the spiders used as provisions by *S. cementarium* are immature Garden Spiders, *Argiope riparia*.



Fig. 116. Four of the favourite spiders used as provisions by the wasp *Sceliphron cementarium*, and the percentage of each found in a large series of cells. (Top row, left to right): (*Epeira trifolium*, 6.55 per cent. in cells; *Phiddipus multiformis* 11.28 per cent. in cells; (bottom row, left to right); *Epeira trivittata*, 7.13 per cent. in cells; *Misumena aleatoria*, 19.67 per cent. in cells. The spiders are shown considerably enlarged.



Fig. 117. A Water Tiger attacking a young eel. This is the larval form of the aquatic beetle *Dytiscus harrisii*.

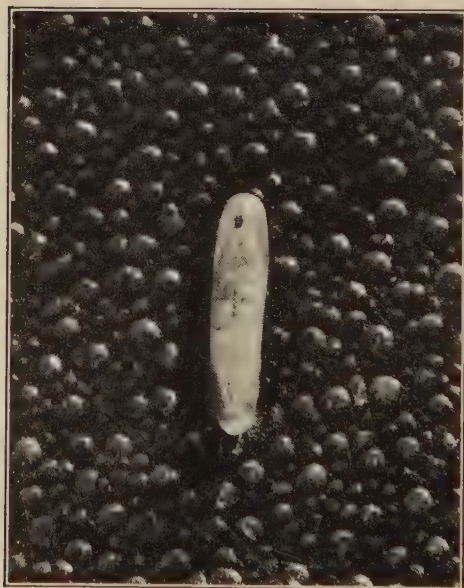


Fig. 118. An egg of the Water Tiger, *Dytiscus harrisii*. Considerably enlarged.



Fig. 119. A young Water Tiger waiting for its prey. Life size.



Fig. 120. A full-grown larval Water Tiger sucking the juices of a tadpole that it has caught and killed. Much enlarged.

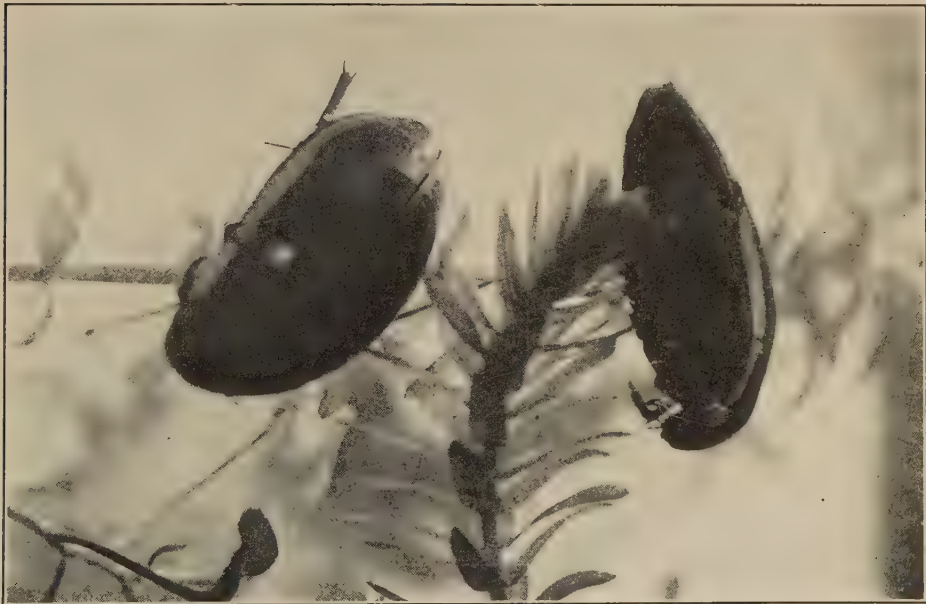


Fig. 121. The adult form of the Water Tiger is this big aquatic beetle. Life-size photograph of two individuals in an aquarium.



Fig. 122. Springtails in their world. Much enlarged. Note that the disk photographed in the background is the exact size of a twenty-five cent piece and compare their size with it.

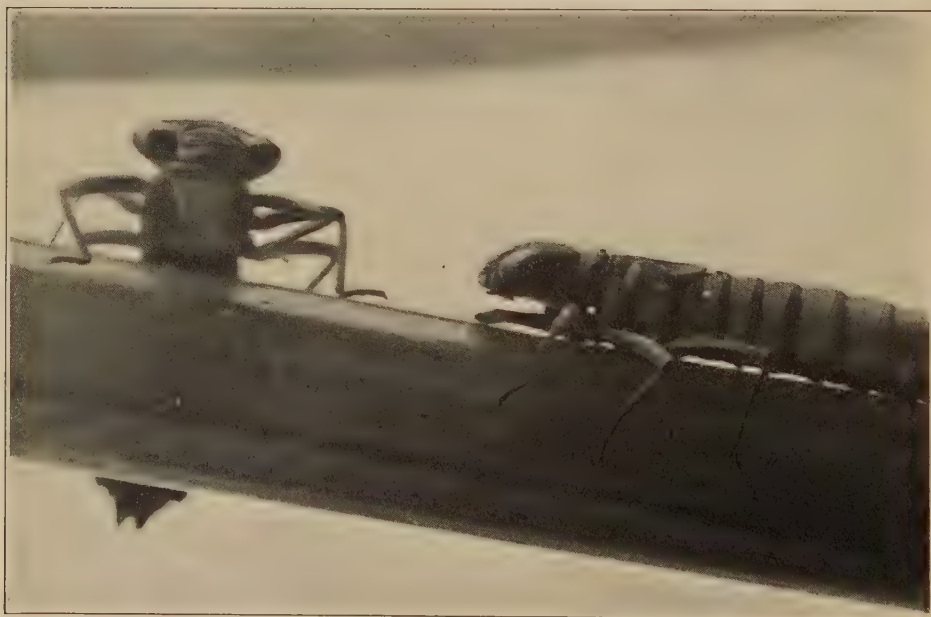


Fig. 123. Nymphs of Dragon Flies. These are fiercely predacious insects, living on other aquatic species and even small fishes.

fore any colour appears in the remainder of the wasp's body. Beginning thus in the eyes and then in the thorax, the entire insect gradually takes on its natural colours of deep blue-black and yellow.

With this pigment come strength and a toughening of the wasp's body and appendages. She moves continually in the cell, and at length her wing bags distend under pressure of a watery fluid from within. This is afterward withdrawn, when the wings dry as thin brittle appendages. Each hour now sees the new wasp more restless. She feels the call of the world of sunlight and finally breaks through her cocoon and attacks the wall of her prison. In a short while she has cut a neat hole through the mortar. She thrusts out her head, smells the perfume of June, and is off, in a few days to build a nest for a new generation. Behind, in the little broken cocoon, she leaves some tiny white beads of excreta. They are apparently all that is left of the ancestral body that is not incorporated in the new.

CHAPTER XIX

THE WATER TIGER

Dytiscus harrisii

LITTLE or nothing appears to be known definitely concerning the life history of this big, common Water Beetle, and it is therefore with much pleasure that I present the following facts:

While searching among the commonest of semi-aquatic plants on the tenth of May, I noticed many slight swellings between the ribs which are prominent in the leaves. Cutting carefully into these swellings, I uncovered glistening yellow eggs which had been deposited singly. They measured seven millimetres in length, and through their delicate shells the larval forms of some insect could easily be seen. (Fig. 118.)

The eggs that I gathered hatched on May 16th, bringing to light our old friend the Water Tiger in its birthday suit. The young Tigers were at once placed in an aquarium, where they immediately took up their war-like attitude and forthwith commenced to eat every living thing that came within their reach. (Fig. 119.) From the very first their appetites were astounding, but they never actually masticated any of their catches, being content to suck their body juices after the fashion of spiders.

Hunting was little resorted to, the usual method of securing their prey being to sit motionless upon the floor of their tank or perched upon a water plant until an unwary creature came within reach of those deadly trap-like jaws. Once I observed a Tiger swim to the surface and grab a wasp that had fallen into the water, but this was a rare feat, performed by a very hungry Tiger.

Those of my insects which were fed copiously reached a large size by summer. Their diet consisted of any living thing at all, together with bits of raw meat. Nothing was too large for them to attack. Fishes, tadpoles, and all sorts of aquatic larvæ or nymphs were trapped with ease, and if not too heavy were borne off to a feeding perch. (Fig. 120.)

The two great jaws of the Tiger evidently eject a poison of remarkable strength as will be seen from the following experiments.

With a large Tiger, separated in a small tank, I placed a small living eel. The fish was panic-stricken, but the insect waited calmly, and without making the slightest motion, until its victim came close to the waiting trap. Then, like a flash, it darted forward and snapped its cruel tongs into the body of the eel. Instantly there was a fierce struggle, the eel coiling its body about its antagonist. (Fig. 117.) The Tiger let go first, but the damage had been done and the eel became rapidly weaker and finally, apparently paralyzed, dropped upon its back. Now the Tiger returned to its prey, seized it, and swam to a water plant to feed in peace.

A young Water Tiger was now given an eel three times its own length. The same thing happened: a few seconds of struggle, a fatal bite, and the corpse of the eel being sucked by a tiny slayer. Once those jaws close and pierce the living flesh, everything is over for the fish or tadpole, or whatever has been attacked, and it is easy to imagine how much damage a few of these Tigers might do where small fish of value are exposed to them.

Many novices have introduced the interesting-looking Tigers into their aquariums upon water plants that have not been properly treated with a solution of potassium permanganate first. Too late they have found their favourite fishes slain, and even then do not always discover the offender.

When full-grown in late summer, the Tiger burrows into water-soaked sod or mud near the edge of the pond. Here it forms a cell and later transforms to a pupa or chrysalis. When it leaves the cell the following spring, it appears as a huge aquatic beetle utterly unlike the larval form. (Fig. 121.)

It is a powerful flying creature of nocturnal habits, often entering houses or collecting about street lights. This power of flight explains its distribution and tells us why ponds that have never been inhabited by Tigers may suddenly develop a substantial crop of them.

The adults are very rapid and powerful swimmers and retain their predacious habits throughout mature life. Their hind legs are curiously adapted to this mode of existence, being supplied with a fringe of stiff

hairs that act as oars. The beetles often rest tail up, at the surface of the water. When frightened, they descend with great speed, carrying a supply of air under their hard wing covers. This may sometimes be seen as a silvery mass or bubble.

The adult beetles may be collected in May or any time after that by dragging a strong net through the stems of water plants in quiet ponds. I have found them numerous in stagnant water and easy to obtain around the 10th of May, when they are breeding and depositing their eggs in the stems of the plants, just beneath the surface.

The larvæ will live in small glass jars or boxes, all that appears to be necessary to their welfare being a plentiful food supply. Several may be kept in the same tank together, as they seldom annoy one another if properly fed. If eggs have been obtained, they require no care at all except to be placed in water.

When the eggs give up their inmates, the investigator will be greatly surprised to observe the size of the young Tigers. It is hard to believe that such comparatively large larvæ could have been packed into such small eggs. In this case, as in most others, where the subject is new to the student, it is such little discoveries that give to nature study its endless fascination.

There are numbers of our commonest creatures about whose life histories nothing at all is known. They offer a most interesting and lucrative field for investigation.



Fig. 124. *Corydalalis cornuta*. The mature, winged form of the Hellgrammite is known as the Dobson Fly. It frequently comes into the house attracted by the light.



Fig. 125. *Myrmeleonidæ*. Greatly enlarged picture of the larva of the Ant Lion. Note its heavy trap-like jaws, with which it captures ants in a neatly constructed pit.



Fig. 126. Life history of the Ant Lion, showing the winged adults and the conical pits constructed in sand by the larvæ. From a model prepared by the author. One half life size.



Fig. 127. The Golden-eyed Lace-wing Fly with one of its curious, stalked eggs. Enlarged three times. The insect belongs to the genus *Chrysopa*.



Fig. 128. The fishing net constructed by the larva of the Caddice Fly, *Hydropsyche analis*.

CHAPTER XX

OUTLINES OF INSECT LIFE HISTORIES

IN THIS chapter, without going into the vast details of the subject, I have written very brief outlines of life histories chosen from among the most important orders of insects. I have been asked again and again to state briefly, and as accurately as possible, the stages through which a certain group or order of insects pass in reaching maturity, and it is remarkable how few people are able to recognize the insect in its early stages. Brief as the chapter is, I believe it will fill a need.

The details of any life history or metamorphosis are intensely interesting, and the patient and enthusiastic student may find these outlines helpful—a skeleton, so to speak, upon which to hang the rest of the story developed by his own observations. Life histories vary, even in a single family, so that it is impossible to give anything but the main facts in these outlines, together with a few notes on the methods of distinguishing the orders to which an individual belongs. Examples of the possibilities of detailed studies of life histories are illustrated in Chapters XVIII and XXI.

All insects possess six legs, and they are easily distinguished from spiders and other similar creatures by this simple means. Their bodies are divided into three parts: head, thorax, and abdomen. They differ from most things in that they do not grow or get larger in most cases after the winged stage is reached. Most of them turn adult all of a sudden, and from that time on there is no appreciable change. The hard outside covering of their anatomy is called chitin, and this material takes the place of the skeleton, and to its inner walls the insect muscles are attached. The inside of an insect's body is entirely filled with fluid or blood and the creature is aerated by means of a system of tubes which have their openings along the sides of the body. There is no lung or breathing apparatus such as we usually think of. The insect is possessed of a heart

and a nervous system but no brain as we think of such an organ. The eyes are either compound or simple, that is to say they either comprise a single eye or large numbers of eyes closely massed into compound organs. The mouth parts are modified in various ways for biting, piercing, sucking, or chewing, and a close study of these modifications will reveal things of very great interest.

As to the number of known species of insects, there are supposed to be in the neighbourhood of four hundred thousand. Doubtless many more than this exist. Within fifty miles of New York City, and therefore within the territory of this book, there are some fifteen thousand species of insects, and these are divided into twenty-odd orders. From these facts it will be seen how brief must be the following outlines in order to condense them into a single chapter. The first of these twenty-two groups follows:

THYSANURA

Fish Moths and Springtails. These are the most primitive of insects. The Fish Moths are those silver insects with long bodies and appendages that one finds among books or papers or starchy things, while the Springtails are those minute objects found on snow, or water, or in damp situations, and that leap enormous distances when disturbed. (Fig. 122.) These creatures pass through no metamorphosis, but simply grow up from tiny to full-grown individuals looking much the same at all periods of their lives. They are all more or less silvery or possessed of a sheen, although some are black. Fig. 122 will easily identify them. Their food consists of starchy material.

PLECTOPTERA

These are the May Flies, delicate winged creatures with three long tails which are seen in thousands in the rays of the automobile lights or collecting in dense masses about the lights in city streets. The female deposits two bunches of eggs in water. From these eggs emerge elongated larvæ with gills along the sides of their bodies which look like feathers. There are also usually three tail "feathers" similar to those of the gills. These nymphs, as they are properly called, live in the water up to three

years, according to the species. When ready to transform to the adult, they crawl to the surface, where the nymphal covering splits and the insect dries itself in readiness for its short winged life. The nymphs moult many times while in the water and once after leaving it; the winged form also moults once. The adults in most cases live but a day, mating, depositing eggs, and dying within twenty-four hours. The May Fly's life history is one of the strangest.

ODONATA

The Dragon Flies, Darning Needles, and Damsel Flies. These, with, perhaps, the exception of the last, are familiar to everyone, but Damsel Flies are simply more delicate Dragon Flies of the suborder *Zygoptera* and differ from their larger relatives in that they hold their wings up like a butterfly when at rest instead of stretched out flat. The young breathe through leaf-like gills which are at the tip of the abdomen. These are absent on the larval Dragon Flies, but both are aquatic at this stage and carnivorous. Our commonest Damsel Fly has a brilliant metallic green body and black or brown wings. The adults deposit their eggs in aquatic plant stems or submerged vegetation, but the big Dragon Flies often drop theirs singly into the water, where the outer gelatinous covering dissolves away and causes them to sink to the bottom. Others deposit strings of eggs on aquatic plants. The nymphs (Fig. 123) spend a long period in the water feeding upon other insects, tadpoles, and even small fishes. Eventually they crawl out upon a stone or plant stem and the winged adult emerges. The adult forms are also fiercely carnivorous.

PLECOPTERA

The Stone and Salmon Flies. The larvæ or young are found usually on stones in streams. They possess two tails and gills that look like hairs. These, when present, are situated close to the bases of the six legs. The larvæ are carnivorous and play an important part themselves as fish food. The adult is winged, with two tails which are much shorter than those of the May Flies, and the wings are gray or slightly tinged with brown or green. There are four wings, the hind pair being the widest, and these are intricately veined. The feelers are quite long and hair-like. The eggs are

deposited in water in spring soon after the adults emerge from the larval water stage.

MEGALOPTERA

The Fish Flies and Dobson Flies. The larva of the Dobson Fly is known to every fisherman as the Hellgrammite or Dobson. It is a tough black creature with heavy mandibles, three pairs of legs, and numerous feathery projections on the sides of its body. It lives under stones and is carnivorous. It is the best bait for bass itself. They remain in the larval stage for two or three years and then leave the water to burrow into the earth near the brook. Here they pupate or transform into a stage which corresponds to the chrysalis of a butterfly, emerging some weeks later as a big, winged insect, gray, with long delicate feelers and two dangerous-looking but really harmless jaws. (Fig. 124.) These are not well developed in the female. The adults frequently come about the lights in our houses and are seldom connected, even in the minds of fishermen, with the Hellgrammite of the river banks. After mating, the female deposits a large number of eggs in a mass on some object close to the water of a stream.

Other creatures which belong in this order, the Fish Flies, are smaller four-winged creatures with feathery antennæ or feelers. They are black or gray or brown with white wing markings and are found near water or about lights at night. The larvæ are found in the water but pupate on land, in earth, or other damp material, emerging in the winged state much as the Dobson Fly some time later. The adults are sometimes very common during the mating flights of the May Flies in the spring. They may also be found near brackish water.

NEUROPTERA

The Nerve-winged insects. Well-known examples are the Ant Lions and Golden-eyed Lace-winged Fly. The first is a winged insect resembling a Damsel Fly with moderately long antennæ, which are knobbed. It deposits eggs in very dry earth or sand and the larvæ, which emerge as Ant Lions, construct conical pits where they lie concealed in the bottom of their traps with only their big jaws protruding. (Fig. 125.) When an ant or other small insect steps on the loose earth at the edge of the pit,



Fig. 129. A Caddice Worm in its tube house, robbing another individual's house of building material. Much enlarged. They may be studied to advantage in an aquarium.



Fig. 130. Houses constructed of various materials by Caddice Worms. These are very common objects in brooks and ponds, the "worms" eventually turn into Caddice Flies.
Twice life size.

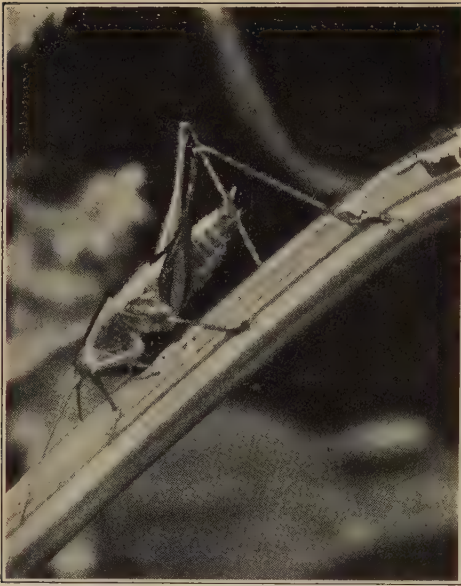


Fig. 131. A young Long-horned Grasshopper or locust. Twice life size. The short wing covers show the specimen to be immature.



Fig. 132. A wingless, Long-horned Grasshopper commonly found in caves and cellars. These are often taken for crickets.



Fig. 133. One of the very few Oriental Mantids ever taken in Connecticut. This species is known as *Paratenodera sinensis*, and has been introduced from the Orient. One native species, *Stagmomantis carolina*, is much smaller. About natural size.



Fig. 134. An Assassin Bug with its victim. Note the long sucking beak beneath the insect's head. Enlarged twice.



Fig. 135. Butterflies hold their wings upright or spread flat when resting. Two Cabbage Butterflies, *Pieris rapae*.



Fig. 136. Spittle masses made by the young of Frog-hoppers. They live within this froth until full grown. Enlarged twice.



Fig. 137. The viviparous aphid. The third insect from the bottom is giving birth to a young one, which may be seen protruding with all legs folded in. Much enlarged.



Fig. 138. Full-grown Tent Caterpillar about to make its cocoon of its own hair. This caterpillar turns into a pretty brown moth, *Malacosoma americana*, but the caterpillars make those great tents on wild cherry and apple trees. Much enlarged.



Fig. 139. The young of flies are maggots as shown here. Some are born from eggs, while others are born alive. They are very important scavengers. Life size.

it tumbles to the bottom and is sucked of its nourishment. The lion spins a cocoon in the earth and pupates within it, later emerging in the winged form. (Fig. 126.)

The Golden-eyed Lace-wing Fly is pale green with gold eyes and a vile odour. It deposits white eggs on long gummy stalks, on leaves or bark. The larvæ are like little dragons and feed upon plant lice. (Fig. 127.) They later spin a cocoon and pupate before reaching the mature form.

MECOPTERA

The Scorpion Flies. These are very poorly named insects, although the tip of the abdomen turns up something like the scorpion. They have four wings which are spotted with dark colours, and their general colour is yellowish brown. Their eggs are deposited in short strings in damp earth, and the carnivorous larvæ live underground. The adults capture other insects, but there is nothing known about the pupa, or in fact any of the details of the life history.

TRICHOPTERA

The Caddice Worms. These are the familiar creatures in ponds and brooks which construct about themselves elaborate houses of sand grains, sticks, and bits of leaves, which are fastened together with silk. The "worms," which are really the larvæ of four-winged insects or Caddice Flies, move their protective house about with them. They feed upon vegetable matter, as a rule, but one species called *Hydropsyche analis* constructs a tube of sand grains in the swift current and near by builds a beautiful miniature fishing net which catches food automatically for it. (Fig. 128.) These may be found by lifting stones from the brook bed and carefully examining them. They are very common but are usually overlooked. The pupal stage is passed within the larval house, but how the adult emerges is not definitely known. Adult Caddice Flies have rather long legs and hair-like antennæ, and hold their wings when at rest against the body after the fashion of Millers or small moths. Trichoptera are indeed supposed to be the ancestors or near ancestors of Lepidoptera, the butterflies and moths.

DERMAPTERA

The Earwigs. These creatures, which resemble elongate beetles with a pair of heavy plier jaws at the tail end of their bodies, were supposed to burrow into people's ears. This is a myth, like so many others concerning our wild creatures. The eggs of the Earwig are deposited under a stone or bit of bark. They are yellow and oval, and the female sits upon them, driving off intruders that inhabit the same shelter. The young look much like the old insects and cluster over the parent when first hatched. They are all introduced species that are found here, and of nocturnal habits.

ORTHOPTERA

This large order includes the Roaches, Mantids, Walking Sticks, Grasshoppers, Crickets, and Katydid. Roaches are hatched from eggs which are carried about, or deposited, in capsules each of which contains many eggs. The young are much like the old ones except in size. Mantids deposit their eggs in more or less cone-shaped masses and cover them with froth which hardens and turns brown or pink. The young are much like the old ones, and they are all carnivorous. Walking Sticks are vegetarians. They drop their eggs wherever they happen to be, and these do not hatch until the following spring. At Toms River, New Jersey, they occur in countless thousands, and a continual pattering of their eggs may be heard as they hit the ground. The young are much like the parents. Grasshoppers and Katydid and Crickets are born much like the old ones, only smaller and minus wings. The Short-horned Grasshoppers—those with short antennæ—deposit their eggs in bunches under ground or in soft wood, into which the female bores with her specialized abdomen. The Long-horned Grasshoppers (Fig. 131)—those with long antennæ—deposit theirs in bark as in the case of the Katydid, or in grasses and stems as in the Meadow Grasshoppers. The females possess long sharp implements at the ends of their bodies for this purpose. Crickets may be distinguished from the Long-horns by their wings, which lie flat upon their backs and their long stem-like ovipositors. They deposit their eggs in the ground but not in clusters. The green Tree Crickets make slits in twigs

for their eggs. The young are much like the old ones except for the undeveloped wings. The Mole Crickets, distinguished by their heavy mole-like digging front legs, deposit their eggs in clusters in the earth in burrows. Specimens often taken for crickets are big active creatures found in cellars or caves. Note that these have no wings. They are really wingless Long-horned Grasshoppers. (Fig. 132.)

ISOPTERA

Usually called White Ants. They are found in rotten wood, among papers and refuse that is damp. They are not ants, but resemble them in their community life. Termites is their correct name, and our only species is *Termes flavipes*. The males and females possess wings and leave the old nests in marriage flights in the spring. The new pairs separate and the males die, but each fertilized queen starts a new colony. She deposits eggs and rears a brood of workers which afterward take care of the growing colony. A soldier caste is also raised for protecting the nest. When the nest becomes overcrowded, the marriage flights occur as stated above. Termites feed upon cellulose.

CORRODENTIA

Book-lice. These are the tiny white or yellowish bits of life that are found on old books or on papers and magazines which are left upon the porch. They scurry off under the page as we read, only to be uncovered a minute later. They are also found on bark and wood. The life history is incomplete, the young being born much like the old ones, except for size. They feed upon paste and dead organic matter.

MALLOPHAGA

Bird-lice. The eggs of the Bird-lice are deposited among the feathers or in the refuse of the nest. They do not bite, but feed upon the feathers, hairs, or scales of the host. The young are much like the parents and reach maturity rapidly, hence the great numbers of them found in a single bird's nest.

SIPHUNCULATA

The true lice, and the biting variety, being fitted with a puncturing beak for the purpose. These are parasites which attach themselves to mammals, including man.

THYSANOPTERA

Tiny black insects of very narrow proportions found usually in flowers. Lutz states that "the young are much like the adults but there is a quiescent stage, just before the mature one, which is very pupa-like and during which no food is taken. Some species (both sexes or only one) never or rarely have wings and sometimes males are absent or rare, the eggs developing without fertilization!"

HOMOPTERA

The Cicadas, Tree- and Leaf-hoppers, Jumping Plant-lice, Aphids or Green Flies, Mealy Bugs and Scale Insects. Cicadas, or "Locusts," as they are improperly called, are familiar insects in July and August, when their loud vibrating songs are heard throughout the day. Their brown cast-off shells are found sticking to trees and buildings. The mature cicada only lives a short time and deposits its eggs in slits in twigs. When the young emerge, they fall to the ground and burrow in. Here they remain for a long period, living on sap which they obtain from roots. When full-grown the larvæ come to the surface and ascend a tree or whatever is convenient, and here the emergence of the adult takes place, much as a butterfly leaves its pupa. The common Cicada is *Tibicen sayi*. The Seventeen-year Cicada, *Tibicina septendecim*, actually remains in the ground in the larval state for seventeen years. The adult lives only for a month or more. It may be identified by the red veins in its wings.

The Tree-hoppers (Membracidæ) are the weirdly shaped little insects with humped backs that leap with great spirit when disturbed. They deposit eggs in plants and the young suck the sap. The young Hoppers moult several times and finally become like the parents, but no pupal stage is found.

The Frog-hoppers (Cercopidæ) are something like the Tree-hoppers

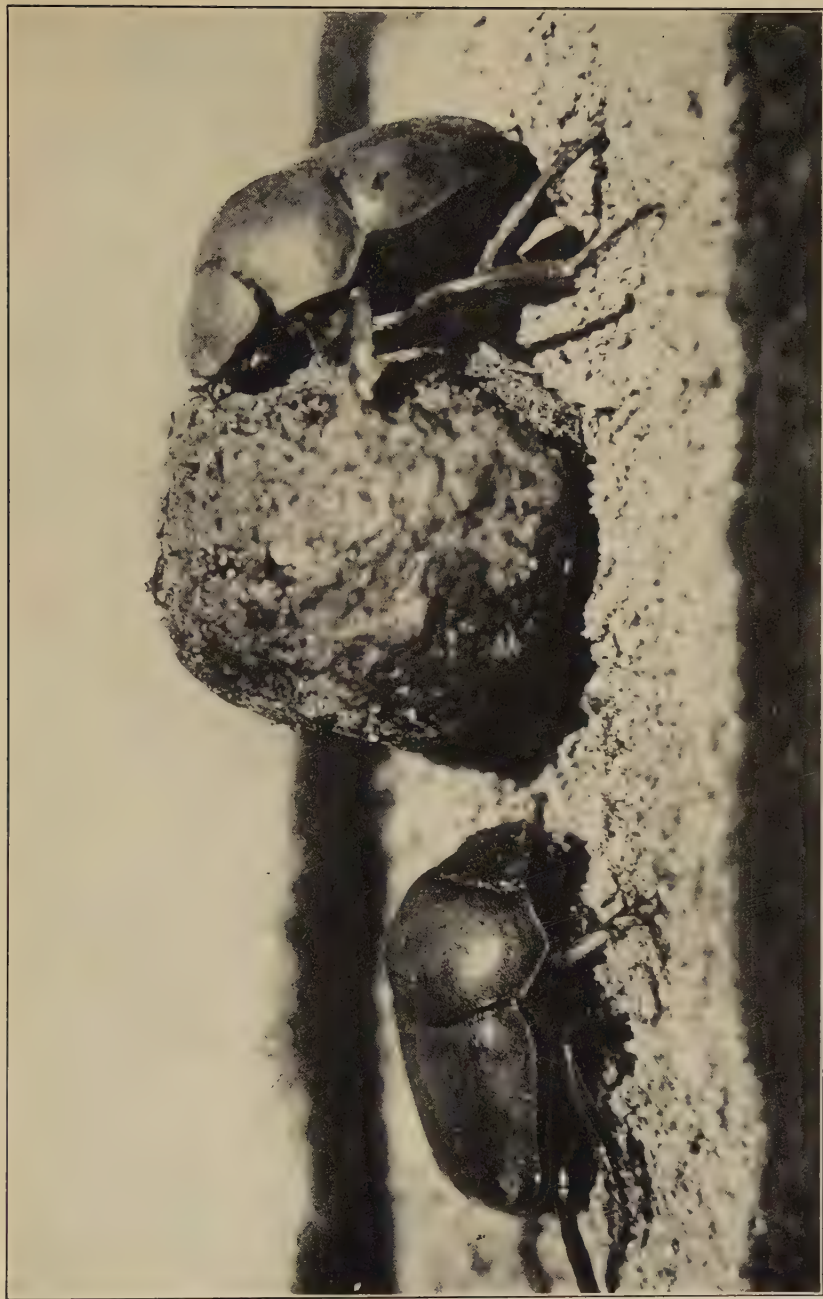


Fig. 140. "Tumblebugs" are Scarab Beetles that bury this ball of cow manure within which their eggs are probably deposited. They roll the ball along as shown here. Much enlarged.



Fig. 141. Some gall-making insects, much enlarged. Note the long ovipositors especially adapted to the work of these creatures.

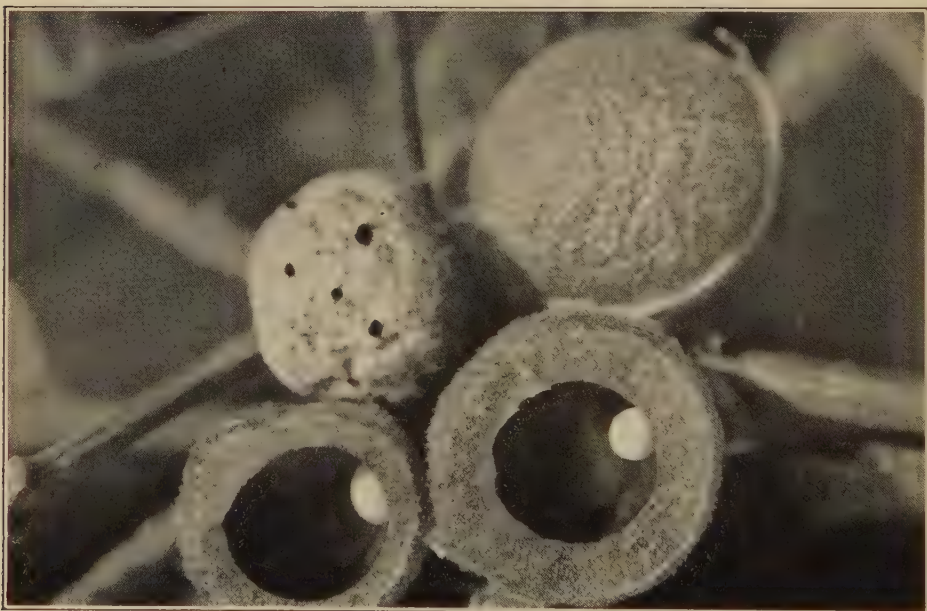


Fig. 142. This Oak Gall contains a loose capsule in which the young insect pupates. Note the old gall from which parasites have issued through tiny holes. Much enlarged.

but with flatter bodies. Their young make the white frothy "spittle" found on grass and plants. (Fig. 136.) In this froth, which is produced by the young, the insects live until they reach the mature form. Their eggs are deposited in the tissue of grass or leaves.

The Leaf-hoppers (Cicadellidæ) are long narrow hoppers found on all kinds of plants and leaves. Many are brightly coloured. They are sap feeders throughout their lives also, but the young do not make spittle. Their life history is much like that of the Tree-hoppers.

The Plant-lice, or Aphididæ, are a great pest, and there are numerous species, some green, others red, and many especially annoying ones are black. (Fig. 137.) Their life history is complicated and is fully described in Chapter XXI.

The Scale Insects (Coccidæ), which give so much trouble to the agriculturist, have very interesting life histories. The males are mouthless and have only one pair of wings. The females are wingless and have a scale-like form as a rule. They live beneath this scale, which is often covered with waxy plates or tufts, or powder. The male undergoes a complete metamorphosis; that is to say, passes through the four stages of egg, larva, pupa, and adult, and in this respect is unique among Homoptera. Scale Insects live on sap, and their excretions cause the honey-dew on leaves and stems which is so eagerly sought by ants. They possess some economic value, as shellac and cochineal are made from Scale Insects. The young insects are either produced from eggs or born alive, as in the case of the Aphididæ.

HETEROPTERA OR HEMIPTERA

The simplest method of identifying a true bug of this order is by its anterior wing bases, which are usually thickened, while the remainder of these appendages is thin. The wings are folded flat, overlapping at their tips. These insects are mostly fitted with sucking beaks, which are plainly visible at the front of their heads. It is a large order and contains the giant Water Bugs (not Water Beetles), Water Boatmen, Back Swimmers, Water Striders and Water Scorpions, Plant, Leaf, and Squash Bugs, Reduvids and Bedbugs, Thread-legged Bugs, Stink Bugs, Flat Bugs, and Chinch Bugs, and some others.

The life histories are, of course, greatly varied, but almost all of them have incomplete metamorphosis, and the young which emerge from their eggs are more or less similar but smaller reproductions of their parents. These youngsters grow rapidly and moult several times, finally becoming mature without undergoing any pupal stage. This applies to the vast majority, but there are some few that have a complete metamorphosis. The Giant Water Bugs carry their eggs about upon their backs, while Water Boatmen, Back Swimmers, and Water Striders deposit theirs upon submerged objects or in plant stems and in dead vegetation. Many of the commonest bugs lay clusters of eggs upon their food plants, and they are easily found, or obtained by keeping the mature bugs in a cage with their chosen food. Some of the Assassin Bugs (Fig. 134) have extraordinary bottle-shaped eggs, and almost all of them are easily bred and studied at close range.

LEPIDOPTERA

The butterflies and moths. The butterflies, which fly by day, possess distinctly knobbed or club-shaped antennæ and fold their wings upright or hold them outspread when resting. They are grouped in the sub-order Rhopalocera. (Fig. 135.) The moths, almost all of which fly by night or dusk, hold their wings against the body or out flat when resting, and possess feathery or hair-like antennæ. These are grouped in the sub-order Heterocera. The difference in the antennæ will distinguish any local moth from any local butterfly, but this would not always hold true in the tropics, for here I have seen insects that I am certain were moths, with distinctly knobbed feelers.

The life histories of butterflies and moths are very much alike in a general way. They all start as eggs, which the parent deposits upon a particular food, usually a plant. Butterflies almost always deposit their eggs singly, while moths very often leave theirs in large clusters. The young are the well-known caterpillars which everyone sees in summer. These emerge as tiny individuals and begin to feed upon the food chosen for them. As they grow the old skin is discarded several times for a new one, and the colour often changes completely with each cast. When they have eaten enough, the caterpillars or larvæ may do one of two things.

If a butterfly, it fastens itself by the tail end, and hangs head-down, or arranges itself head-up, fastened by the tail end and with a thread about the upper part of its body as a support. The fastenings are of silk, spun by the larva. In this position it transforms to a pupa or chrysalis, and later emerges as a winged butterfly.

The caterpillars of moths very often spin an elaborate silken cocoon or construct one from their own hair bound together with silk. (Fig. 138.) Within this cocoon they pupate, but they do not fasten themselves within the cocoon. Others burrow into the ground and pupate in an earthen cell or go under stones or bark for this purpose. A naked, hanging or silk-supported pupa is almost certain to be that of a butterfly, while an elaborate cocoon or earthen cell containing a pupa will usually turn out to be that of a moth.

Pupæ which are made in the spring or early summer usually hatch during the same season, while those made in late summer and fall often winter over. Many eggs also winter over.

The caterpillars of the Lepidoptera will be found on almost every kind of vegetation, on leaves, within stems, flowers, and fruits, on grasses, and in all kinds of strange places.

DIPTERA

The true flies. They may be identified at a glance by the fact that they possess only one pair of wings, back of which are a pair of knobbed projections called halteres, which are supposed to act as balancers. The order includes House Flies, Mosquitoes, Gnats, Crane Flies, Bluebottles, Midges, Flesh Flies, Horseflies, Bots, Robber Flies, Fruit Flies, and countless others. (See Figs. 82, 83.)

Many flies deposit eggs, while still others, such as the Flesh Flies, whelp their young upon dead animals, meat, or other filth. Young flies are maggots and familiar to all of us, while the pupæ may be little brown oval kegs or mummy-like things resembling the body of the mature insect. (Fig. 139.)

Flies deposit young and eggs in every kind of medium—water, mud, leaves, flesh, manure, other insects, living animals and birds, vegetables, refuse, and, in fact, in almost everything. There are thousands of species

in North America alone, and they breed so fast that dozens of generations are possible in a single season. The pupal stage may be passed in the food medium, in a living host, on the ground, and in every sort of place. The life histories of the individuals of this order are far too diversified to make any general statements other than those given above.

SUCTORIA

The fleas. Fleas are born from eggs, which in the case of the Dog Flea are deposited among the animal's hair. These eggs drop out, and if the situation in which they lodge is favourable, the young fleas emerge and crawl into cracks or into furniture coverings or almost any sort of a dust-catcher. Here they feed upon the dust and dirt. They are nothing like the adult fleas. The body of the larva is long and maggot-like, made up of thirteen segments and an eyeless head. Protruding from each side at the indentation of each joint there are tufts of bristles or hairs. After feeding for a week or more the larva spins a flimsy cocoon and pupates within this covering, or it may simply undergo this transformation uncovered. When the adult emerges from the pupa, it hops about until the correct host is found. There are many species of fleas found on various animals, including man, who has his own particular variety.

COLEOPTERA

The beetles. The vast majority of beetles with which we come in contact may be recognized as such by the fact that their front wings are very hard. These lie folded straight along the back, and there is usually an indenture or straight groove where these two wings meet called the suture. Under these hard covers are the other pair of soft, often transparent wings, which do the actual work in carrying the insect about. Their mouths are well fitted with chewing apparatus, and their antennæ are of all lengths and forms. Some families, such as the familiar Rove Beetles (*Staphylinidæ*), have short wings which do not cover much of the body. Not all beetles have the hardened front wings, but the majority have. (Fig. 80.)

Some familiar typical beetles are such creatures as Ladybugs, Potato

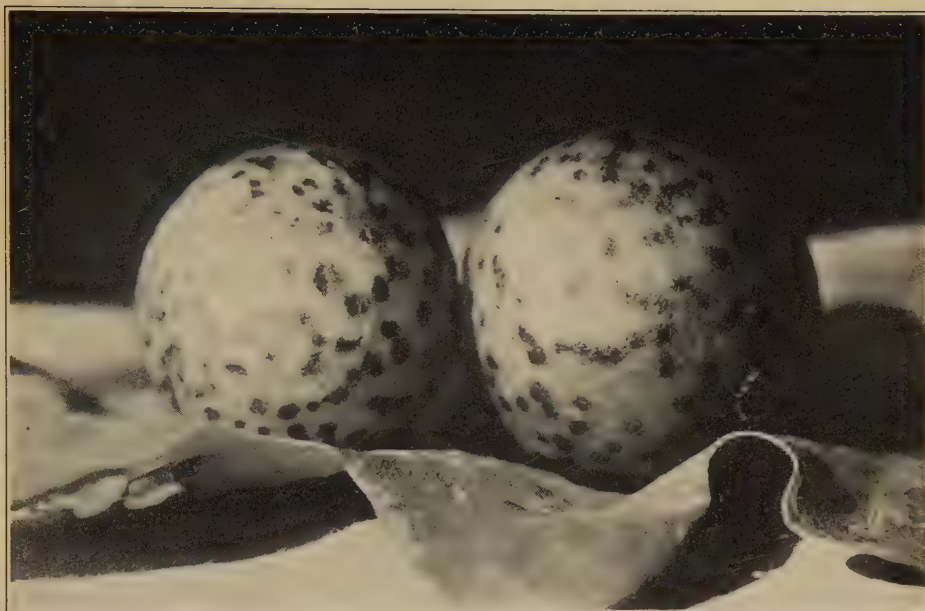


Fig. 143. Exterior of the galls as shown in Fig. 95. Much enlarged. They are green, with purplish red spots.



Fig. 144. This gall, found upon Hackberry, is made by *Pachypsylla cucurbitæ* (Homoptera). It is shown much enlarged.

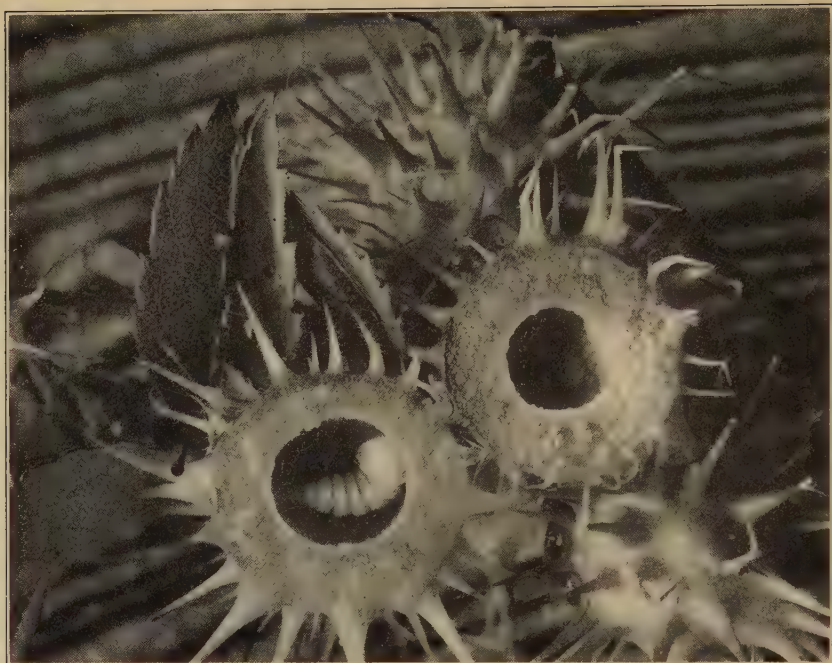


Fig. 145. Spiny Rose Galls cut open to show the larvæ of the insect. This species is called *Rhodites bicolor*. Much enlarged.

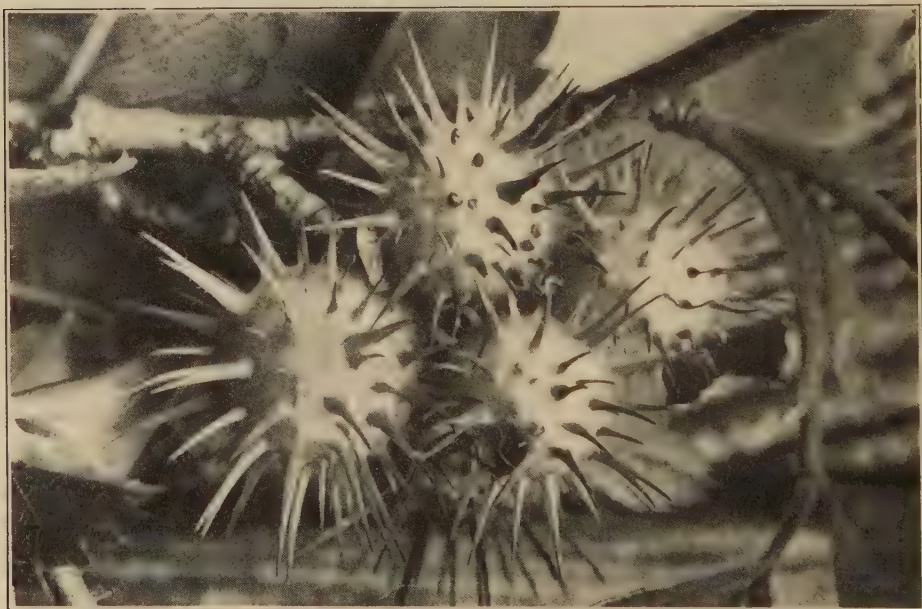


Fig. 146. The most beautiful of all the local galls is the Spiny Rose Gall, *Rhodites bicolor*, made by a small wasp-like insect. The galls are green and pink in summer and brown in winter. Much enlarged.

Bugs, Rose Chafers, June Bugs, Snapjacks, Fireflies, Scarabs, and Weevils. There are thousands of species.

The life history is complete, having four or more stages. The eggs may be laid in wood, in the stems of plants, on leaves, manure, carrion, and in all sorts of food materials. The larvæ are varied in form, some very grotesque, and most of them are more or less grublike. The big fat grubs turned up by the spade or plough are familiar forms, and these turn into June Bugs. Many larvæ are borers in wood, dead and living, while still others are predacious, feeding on other insects. Some beetles spend most of their time in the water (Chapter XIX), and still others live in or near carrion, some for the insects it attracts, some for the food itself.

The pupæ of beetles often resemble white, folded-up adults, and these are of course found in as varied situations as the larvæ.

GALL INSECTS

Before going on with the final order of insects, the Hymenoptera, I must say a few words here about the gall makers. You have doubtless seen the strange swellings upon the leaves and stems of trees and plants, many of which are of interesting and beautiful form, and within which you have found maggots, or curious tiny six- or eight-legged creatures. These growths upon plants are called galls and are produced by various orders of insects, and some of the mites. (Figs. 141 and 142.) The eggs are deposited upon or in the food plant, and the young are soon enclosed within a gall, which results from the irritation of the plant tissue. Each gall insect produces a certain form of gall, and most of the species may be identified by these at a glance. Why such strange and beautiful things should grow over the feeding young of these creatures is a mystery. Some are green balls, filled with silk-like radii, which support a central capsule in which the young insect lives. Another, the spiny rose gall (Fig. 145), is also a ball of green and pink tissue, covered with long sharp spines of the same colour. There are galls that resemble a cock's comb on elm leaves and interesting forms on nearly every tree.

Galls are caused by mites (*Acarus*, etc.) and by members of four insect orders, Homoptera, Lepidoptera, Diptera, and Hymenoptera. The galls made by the mites may be identified, if inhabited, by the fact that the

owners have four pairs of legs. The common swellings found on the stems of goldenrod are galls made by a small Lepidopterous insect, a moth belonging to the Tortricidæ. Most of the galls, you will notice, will contain white grubs or maggots, and these are usually the young of either Dipterous or Hymenopterous gall-insects. (Figs. 141-146.) Remember, however, that gall insects have their parasites, and the inmates may not always be the producers of the growth. (Fig. 95.)

HYMENOPTERA

This great order includes the Sawflies, Bees, Wasps, Ants, Ichneumon Flies, and other less familiar insects. The life histories of these creatures include four stages: the egg, larva, pupa, and adult. The Ichneumons are of very great economic importance, as countless hordes of them parasitize other insects, and they are therefore the destroyers and perhaps the special natural check upon harmful insects. They resemble Wasps more than anything else, and many of them may be identified at a glance by the presence of a long ovipositor with which they puncture the protective covering of their hosts. One which is often noticed is a large wasp-like creature with three long "tails" about as thick as a horse hair. These tails are several inches long and constitute a drilling machine and ovipositor. The insect drills into solid wood with this flimsy apparatus to reach the larvæ of the Pigeon Tremex, *Tremex columba*, which is a large Sawfly. (Fig. 94.) In these larvæ it deposits its eggs. All kinds of insects, young and old, are parasitized by Ichneumons and Chalcid Flies. These last are tiny insects about an eighth of an inch in length or less, often with a long ovipositor. This issues from the female's body on the under side, some distance from the end of the abdomen. Whole broods of tiny parasites will sometimes issue from a single caterpillar, or perhaps a single large one. The tiny white cocoons sometimes seen all over the back of caterpillars are those of small Hymenopterous parasites that have lived their larval life as maggots within the host and have emerged to spin their cocoons and complete their metamorphosis in the outer world. A careful observer will find parasitic Hymenoptera almost anywhere, and much remains to be learned concerning them. Some of these parasites are treated in more detail in Chapter XIV.

Ants need no description, as we all recognize them. Their communities are very remarkable and their social organization has been written about for centuries. Glimpses into their homes and daily lives will be found in Chapters XIII and XVII.

All our numerous Wasps, with the exception of the familiar Hornets, Yellow Jackets, and Paper Wasps, and a few others, are solitary species. That is to say, the female makes a nest, which may be of mud, or in a burrow made by the wasp in the earth, or in a stem or hole, and this she provides with suitable food for the young. The food may be spiders or other insects paralyzed by her sting. This is placed in separate cells and an egg is deposited on each food mass and the cells are usually sealed up. The young Wasp, which is a footless grub, consumes the living food and afterward pupates, issuing still later as a mature Wasp. The stories of the lives and habits of the solitary Wasps are among the most interesting in all the realm of nature. One of these is fully told in Chapter XVIII.

Hornets and Paper Wasps live community lives, the fertile queens who have hibernated starting the new colonies in the spring. After the raising of the first brood (the workers—non-reproductive females), the queen simply lays eggs and the workers enlarge and care for the nest and do all the work, including the raising of the young. The larvæ of these social species are fed from day to day by the workers until ready to pupate, when they spin silken caps to their cells and later emerge as adult workers. Later in the year broods of males and queens are raised which pair in the fall, the males probably dying, and the fertile queens again wintering over.

Among Bees, most of which may be told from Wasps by their stocky and much more hairy bodies and hairy hind legs, we find some social species such as the Honeybee, Bumblebees, and the like, but the vast majority are solitary, each female, or sometimes apparently a pair, making a nest which is stored with honey-paste (pollen and honey or plain pollen) and upon which the egg is deposited. The young Bee is a footless grub also, and it feeds upon the stores laid up for it, afterward pupating within its cell. Bees make burrows in the ground, or use ready-made or manufactured holes in wood or stems of plants. The Leaf-cutter Bees (Mega-

chile) construct beautiful cells of green leaf fragments or flower petals within a suitable hollow or plant stem. Other Bees construct earthen cells under stones, as do some of the solitary Wasps.

Bumblebees live in communities with a queen, making their homes in the abandoned nests of mice either in the ground or in buildings. They raise their young in cells on pollen and honey, and the queen raises the first spring brood of workers herself, as in other social Hymenoptera.



Fig. 147. Finally came larger Ichneumons, Paper Wasps, Bees, and Butterflies, to lick up the sweet exudations. Bee at the left. Ichneumon at the right. Much enlarged. (See Chapter XXI.)



Fig. 148. The dragon-like young of the Ladybug feeding upon the Aphids. The Ladybug is really a beetle named *Adalia bipunctata*.



Fig. 149. A great herd of sucking Aphids and in the centre part of the leaf a group of the Ladybug's long yellow eggs. Much enlarged.

CHAPTER XXI

INSECT ASSOCIATION ON A ROSE BUSH

GROWING about the steps of my porch, and covering my doorway in June with an avalanche of blood-red flowers, is a rambler rose of exquisite beauty. Late in May the inevitable colonies of tiny green Plant Lice appear upon it, from the minutest of eggs that have been tucked away, no one knows where, during the winter months. Although these soft green suckling bugs appear thus from perfectly conventional eggs, it behooves them, a few days after birth, to beget others of their kind by the much more advanced process of live birth, and so in a week or two a single aphid may become the mother of a great number of others who in turn become mothers themselves a few days later. The result is that by early June, when one begins to think of roses, the whole plant may be covered by countless aphid mothers, grandmothers, and great-grandmothers, each sucking its tiny bit of the vital sap from the struggling bush, with the result that its leaves begin to shrivel, its buds appear to make no progress, and the whole glorious plan of blossoming becomes more and more in danger as the days progress.

It is now that we who love flowers generally enter with our nicotine solution and sprayer. We coat the whole buggy colony with fine deadly spray. Once, twice, we do this, and the pests fall off in numbers. A third time we douse the offenders, and our rambler or rose is free once more to thrust forth its blossoms in all their glory.

Now it so happens that I am a lover of flowers, but yet a seeker after knowledge, and a lover of insects also. It is strange that such a conflict should take place in anyone, yet it has in me, to the extent that this year I decided to allow my rambler to remain unsprayed.

To justify this apparent crime I have but one defence, and that is the same defence that every naturalist or scientist offers in such cases. I was willing to sacrifice my rambler for the sake of truth. In other words, I

wanted to know how Nature would endeavour to counteract the curse she had placed upon this struggling plant. Would she destroy it wantonly because I, another of her children, had laid my sprayer upon the shelf? Not altogether, I imagined, and here is what I observed:

A day or so after the bug colonies appeared upon the leaves of the rambler there were numerous little red beetles with two black spots upon their backs there also. These were our familiar Ladybugs that we so often tell to "Fly away home," and here among the aphid colonies they were doing two very important things. They were depositing masses of long yellow eggs close to the sucking herds, and at the same time eating their fill of the helpless creatures. A week later there were still more Ladybugs to be found, more yellow eggs had been deposited, and numbers of the first ones had hatched, and from them appeared the dragon-like youngsters in jet-black coats, and supplied with two powerful pincers protruding from their heads. (Figs. 148 and 149). All these set about at once to devour Aphids, beginning with the tiniest individuals and increasing the size of their victims as they grew from day to day.

Before long there were great numbers of Ladybugs in every stage of growth among the colonies of destroyers upon the rambler. All day long they gnawed and chewed away, and when by night I made observations, all these tiny jaws were still doing their best to relieve the plant of its misery.

All at once, on another day, there came a new army to help the Ladybugs in their one-sided battle. These were little Wasps in shining black armour. Hundreds of them poured into the rambler, and each one, with the deftness of a hawk, snatched away a struggling aphid. They were so business-like and so swift that I admired them greatly. Near by, in the abandoned beetle-borings in my rustic porch columns, I saw these tiny Wasps making their nests and stuffing them with the unfortunate Aphids for their own young to browse upon. (Fig. 151.)

Some of the Aphids now began to swell up like balloons. Soon they became anchored by paralysis and turned a shiny brittle brown. Then all at once tiny Ichneumons would issue from them, through neatly drilled circular openings in their ravaged bodies, and I realized that the parent

Ichneumons had slyly deposited eggs within the Aphids entirely unobserved by me!

There were three species of Dipterous flies attacking the green hosts. One, a Robber Fly, took its victims one by one to a near-by twig and devoured them leisurely. A second ate them without removal, while the third, a black and yellow fellow called *Syrphus americanus*, deposited single eggs among the herds. These flies did not eat the Aphids themselves, but from their eggs emerged slug-like larvæ that fed copiously upon them.

Wherever we find Aphids, we find Ants also, for, as we all know, the Ants understand how to obtain a sweet fluid from them. This they do without injuring them. In fact, they actually cultivate and protect the herds for this purpose, and the association between these two kinds of insects is world-wide, and very common.

The Ants tending the herds upon my rambler were of two varieties, the common Carpenter Ant and the equally well-known Red-bodied Mount Ant, both of which had nests near by.

When the *Syrphus* flies were about, these ants became very nervous and pugnacious, acting almost as if they realized that it lay within the power of these creatures to destroy their milking herds. They would dart about upon a leaf and actually forcibly remove the flies that tried to deposit their eggs among the Aphids.

As the days went by, a great number of insects could be seen busy about this rambler bush. Hordes of them came from the surrounding country and were held by this isolated lure. Each had a niche to fill, each a relation with something else about the plant, until it became a buzzing, whirring hive of industry and destruction.

Finally came larger *Ichneumons*, Paper Wasps, Bees, and Butterflies, for the single purpose of licking up the sweet exudations from the Aphids, which now covered the leaves with dark, sticky blotches. In performing this service—for such it was—these insects received sweets in return. Only clean leaves can function properly in the sunlight. (Fig. 147.)

My observations repaid me for the sacrifice of this rambler, but in the end it was not a complete sacrifice. The plant lived and bloomed, and to-

day it is as well as ever, although it was indeed very ill for a time. Neither is this chapter a plea for Aphids. Far be it! Spray them, kill them, by all means, for such a helpful association of insects as I have described may not often be met with. What I observed teaches us a graphic lesson, just the same: that wherever a child of Nature is in real danger of destruction, an army is ordered against the peril that at least checks the invader, and returns to the persecuted its chances for life.

CHAPTER XXII

SOME COMMON FISHES OF SALT AND BRACKISH WATER

THERE are many common and interesting fishes in our local waters. I am frequently asked for information in regard to these, but it is difficult to cover them adequately in the space of one or two chapters.

As in the rest of this book, in these chapters on fishes I have grouped the animals treated in ways that I believe will be helpful to the one seeking information in regard to habits and biology, and have paid little or no attention to classification, which it will be the business of the more scientifically minded to pursue in volumes other than this one.

I have separated the common local fishes into two groups, those which are commonly seen or caught in salt and brackish waters, and those which are found in the fresh streams, ponds, or lakes. In the case of the Eel, which is really a fresh-water fish, I have placed it in the first group, because I believe that in most cases a person looking for information in regard to this species would turn naturally to descriptions of salt and brackish water varieties.

COMMON EEL

Anguilla chrisypa Rafinesque

Contrary to the belief of many fishermen and others, there is only one Eel in our waters. Eels are found in the salt coast waters and in lakes and ponds far inland. The reason for this divergence in habitat will be readily understood when we know something of the Eel's life history.

Eels are true fresh-water fishes, but they come down to the sea to spawn, usually in the fall. They reverse the process of such species as the Smelt, which ascends to fresh water to deposit its eggs.

For years, mud banks off the mouths of rivers were the sworn spawning grounds, according to naturalists who were willing to make state-

ments without having any actual knowledge of the facts. How wrong they were, you will soon see, and no grosser error was ever made by man than this one concerning the Eel.

The spawning grounds have now been definitely established by scientific expeditions with their deep-sea dredges and other apparatus. They lie between Bermuda and the Leeward Islands, where the water is extremely deep. To this strange spot in the sea come the Eels from two continents, our American species and the individuals from Europe. All the way from remote ponds and lakes the mature Eels travel to deposit their eggs in these far-away waters, and once they have gone to sea they probably never return.

The minute eggs are deposited some 650 feet below the surface. When the larvæ hatch, they are quite unlike Eels, being rather flat and wafer-like and very tiny. As they grow, they ascend, and commence their long, slow journey to our northern shores.

When they reach, for instance, the inlet back of my house in Noroton, Connecticut, in May, they are perfect but tiny eels, as transparent as glass, and as delicate, it would seem, as that fragile substance. (Fig. 156.)

How marvellous to stand here, but a step from the house, and find these tiny "elvers" that have travelled through all the terrors and perils of the sea, the selected few, among millions, that have reached my pond successfully!

Once the young enter the inlets, they work themselves up to the streams that empty into them. On they go to places far inland, and here in pure, fresh water, they live until maturity urges them to the sea again, to spawn as their parents spawned before them.

The male Eel was not discovered until 1873, when Dr. Syrski of Trieste made his studies which brought much valuable information to light.

The ovaries of the female are two yellowish or reddish-white elongate bodies, as broad as one's finger, lying alongside the backbone, arranged in numerous transverse folds, extending throughout the entire length of the abdominal cavity. These two bodies are so large as not to be easily overlooked, but they contain such a quantity of fatty cells, and the eggs imbedded in them are so small and delicate, that one might easily believe, even after a superficial microscopic examination, that the whole organ consists of fat. The testes, or male spermatogenic organs, are not ribbon-shaped like the ovaries, but represent two longitudinal rows, each with about fifty lobules. These spermatogenic organs can be dis-

tinguished at once from the ovaries, not only by their lobular form, but also by their shining, glassy appearance.¹

On May 16, 1924, I found large numbers of young Eels three to four inches in length in Gorham's Pond at Noroton. They were in the Algæ that grow about the edges of such inlets at this season. Many of the largest Eels were greatly swollen in the centre, and upon opening some of these I was surprised to find masses of fish eggs, which the uninitiated would certainly have taken for eggs of the Eels. The truth is that in this place numerous Sticklebacks build their nests and the Eels have taken advantage of this fact. At this date there were also present great numbers of much smaller Eels. These were as clear as glass, except for their dark, refuse-filled alimentary canals and tiny backbones.

On the 16th of April, 1925, I was successful in making an unusual observation—that of the young Eels newly arrived from their far-off hatching grounds ascending to fresh water, directly from the salt water of the Sound.

There is a certain place in Noroton which is particularly well suited for the purpose of such observations, on Scott Cove. Here a tiny brooklet connects the outlet of a fresh-water pond with the salt water of the inlet, and the entire distance between the fresh- and salt-water bodies is about 200 feet.

The distance that the freshly arrived Eels must travel from salt to fresh water is thus very short, and they reach the dam of the fresh pond almost at once.

On the morning in question, I found the tiny Eels working their way up this brook, and observed many at the base of the dam. One or two others were seen actually wiggling into fissures in the masonry, through which water was leaking, while in the pond itself I caught six with my net. Thus in a single morning I had the good fortune to observe the whole journey of baby Eels from salt to fresh water!

This is the earliest date that I have ever found the young Eels in the inlets, but the spring of 1925 was particularly mild, following an almost open winter.

¹Jordan and Evermann: *American Food and Game Fishes*, p. 78.

The record Eel I believe measured forty-three inches in length and weighed six and one half pounds. The average in this locality does not appear to exceed three feet.

They are caught in many ways: by spearing, by hook and line, and by trapping. A very sure method of obtaining Eels is to bait a funnel trap with Killies, leaving it in shallow water overnight. I have also caught them readily by lowering my smelt-tackle below the area where the Smelt were being taken. This holds true especially if the fishing is done from a bridge near a tide gate, as the Eels collect here in numbers until the gate opens and liberates them.

MENHADEN OR MOSSBUNKER

Brevoortia tyrannus (Latrobe)

The Menhaden is a stout fish reaching eighteen inches in length. It is bluish on the back, with silvery sides that have a brassy colour or sheen. There is some yellow upon the fins and a very noticeable dark, more or less circular blotch just behind the upper part of the cheek on either side. This blotch is often followed by other smaller dark spots. The fish has a very large head and mouth.

The Menhaden comes into the inlets where the water is brackish in late spring, and may possibly spawn here, although in my experience the eggs are not more than half formed at such times. On rare occasions ponds connected with the Sound by tide gates have been found filled with these fishes, which have entered with the flood tide only to be trapped when the gate closed.

An individual which was collected by the author in the inlet at Norcton on June 13, 1924, had been attacked by a strange parasitic Copepod crustacean known as *Lernæenicus radiatus* (Lesueur). The fish kept rising to the surface, where it would splash about for a time and then descend again, only to return in a minute or so. I caught the fish easily in my hands. It weighed two and one half pounds and appeared to be in fine condition. A close search, however, revealed a strange object protruding from the side of the fish close to the base of the caudal fin.

This object (Fig. 155) resembled a flesh-coloured tube of very small diameter with an elongated swelling at one end, which was open like a

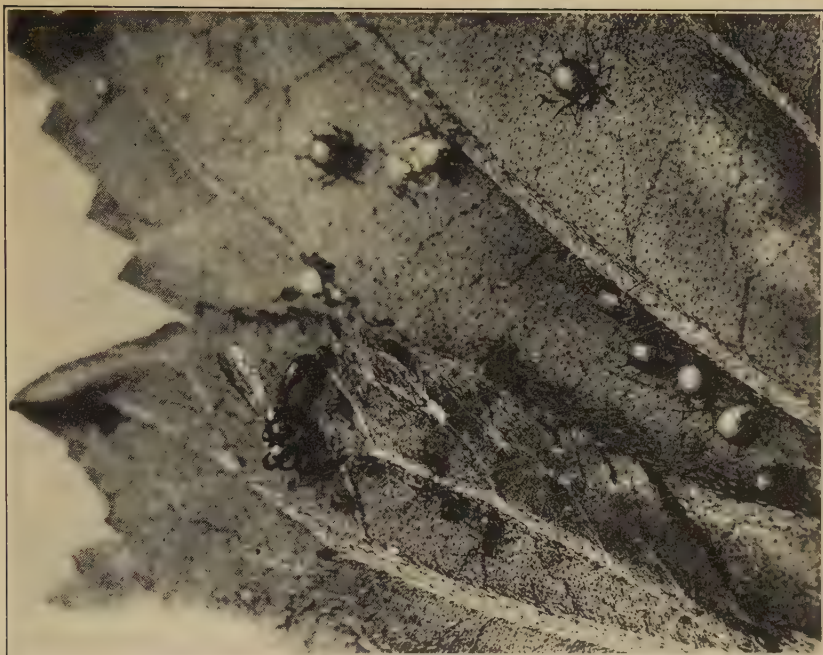


Fig. 151. At the top we see one of the little wasps in shining black armour that preyed upon the Aphids. Below are a number of Aphids swollen like balloons and containing Ichneumon parasites. Greatly enlarged.



Fig. 150. A rambler leaf, showing pupæ of the Ladybug and a newly emerged insect at the lower left. The pupa corresponds to the chrysalis stage in butterflies. This photograph shows insects enlarged about four times.

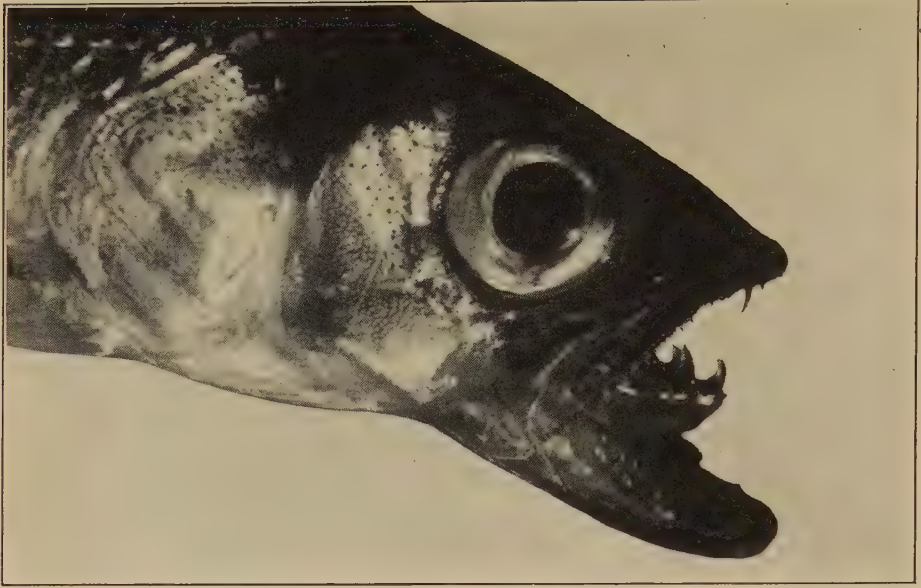


Fig. 152. Head of the American Smelt, *Osmerus mordax*, showing tongue and teeth. Much enlarged.



Fig. 153. Head of the Common Herring, *Clupea harengus*. Compare with Fig. 154. This photograph and the one at the right illustrate the two fishes slightly larger than they are when they enter the local inlets in September.

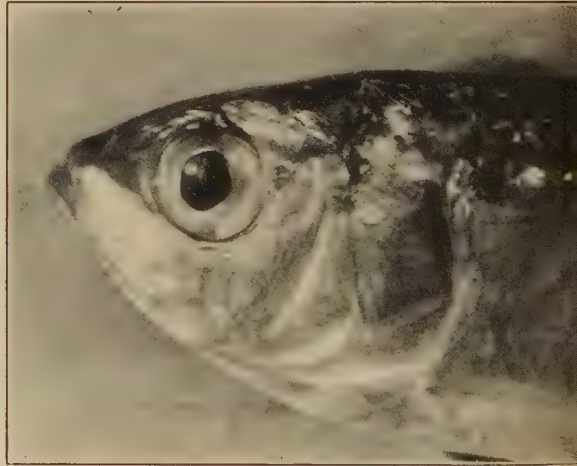


Fig. 154. *Pomolobus pseudoharengus*. The Alewife is much like the Common Herring in colour, but is shorter with a less elongated head. Compare with Fig. 153. Herrings and alewives are often associated in large schools.

mouth. The other end, which was fastened in the tissues of the victim or host, was held firmly in place by four radiating finger-like processes which could not be seen until the parasite had been extracted.

Menhaden are not good to eat but are caught in large numbers for their oil.

On May 19, 1925, the inlet back of the author's house was visited by a considerable number of these fishes. They were very active, rapid swimmers, going about in pairs, one circling about the other and occasionally leaping out of the water altogether, landing with a loud splash. These actions continued throughout one night and the next day.

This visitation entered the inlet on a high tide that swept in on the night of the 18th of May, and the fishes remained in the shallowest part of the inlet among the rank growth of *Algæ* and sea lettuce. I could find no spawn, however.

On the 20th, I set a large funnel net, concealing it in the *Algæ*, as I noticed that the fishes kept darting through it. My plan worked very well, and on the following morning I had a fine Menhaden, with its fins considerably battered.

Examination of its stomach showed vegetable matter and large numbers of microscopic organisms.

THE CHOGSET OR BERGALL

Tautogolabrus adspersus (Walb.)

This abundant fish is commonly met with in both salt and brackish waters, although it avoids places where the percentage of fresh water is very high. It is very variable in colour, but is usually decidedly bluish, with reddish or bronze tints and obscurely barred with dusky tints. The bars do not always show. Teeth well developed and lips large.

The Bergall belongs to the large family of Wrasse-Fishes, most of which are tropical species. They are not very good food fishes and are certainly a pest at times to the fisherman, stealing his bait each time his line is thrown overboard and as often hooking themselves and making trouble generally.

They are scavenger fishes, eating almost anything, and their powerful and very noticeable teeth are well fitted for such work.

THE TOMCOD OR FROSTFISH

Microgadus tomcod (Walb.)

The Frostfish is in reality a very small species of codfish. It is particularly common in the fall and early winter, when it enters the inlets and travels to fresh water to spawn. Frostfish are caught every year from the bridges and piers, and I have taken many of them on smelt tackle off the bridge at Gorham's Pond at Noroton. They are also found along the shore at other seasons but enter the inlets only at spawning time.

In colour the Tomcod is variable, but the upper parts are usually dark olivaceous, with irregular marks and blotches, so that the fish appears mottled. The under parts are silvery white, sometimes yellow in the females. There is considerable red and yellow and brown in the fins, and a small barbel protrudes from the lower jaw. The fish is oblong, with small smooth scales and double nostrils, the anterior pair being the larger. Length less than one foot, very rarely exceeding that length.

Stomach examinations of these fishes show that they feed upon Killies and others small fishes, as well as mollusks and crustaceans, such as Shrimps.

The species ranges from Virginia to Cape Sable.

THE AMERICAN SMELT

Osmerus mordax (Mitchill)

This is one of the best known of our anadromous species (Fig. 152), appearing in the inlets that lead to fresh-water spawning grounds in September. Here it is sought by fishermen of all ages until late in the winter, catches often being made through holes chopped in the ice.

Smelts come into Gorham's Pond in Noroton and may be caught here upon Shrimps and Killies which abound in this body of water.

In catching Smelts, I use a spreader with two hooks, baiting one with an entire small Killy, passing the hook through its back without paralyzing it. When in the water a fish so hooked remains in an upright position and swims about. The other hook I bait with a well-crushed half Killy. One of these two baits will usually attract the Smelts if they are about.

In colour the Smelt is a beautiful transparent sea-green above, with brilliant silvery sides. It is long and narrow and reaches a length of ten inches.

Smelts are really small Salmonidæ, although they belong to the family Argentinidæ. They are very much like small Trout in the details of their anatomy, except for the form of the stomach. The interested student of nature should examine the wonderful mouth and teeth of a Smelt. Not only is this fish supplied with powerful teeth in its jaws, but veritable teeth also grow from its tough tongue! These turn backward in such a manner that when its prey is once in its grasp, nothing can remove it. Smelts are fierce and voracious fishes, tirelessly hunting and devouring fishes and crustaceans.

THE SPEARING OR SAND-SMELT

Menidia menidia notata (Mitchill)

The Spearing (Fig. 157) is the common bait shiner that is caught in huge numbers along the shore and inlets in seines. It is also called White-bait when young, and is used for catching Snappers and other fishes, and in addition is cooked like straw potatoes and eaten with relish by man.

The species reaches five inches or more in length, and is translucent sea-green above, with a broad silver band on each side of the body extending from the branchial aperture to the tail. The jaws are fitted with hooked teeth and the eyes are large and silvery. The scales are marked with minute black dots.

This species spawns in the inlets in shallow water and the fry appear in the middle of June. Thereafter, fresh broods continue to appear for several weeks.

They swim in compact schools close to the surface of the water, and are among the most beautiful and most delicate of our fishes. The slightest shock will kill them, and even the change from their natural surroundings to the pail or collecting can is fatal unless accomplished with great rapidity and without touching the fishes. They will turn upon their sides and die almost without cause. It is possible, however, to keep them alive in an aquarium at times, and they will feed upon dried Shrimps and the natural food that is in the water, but their lives will be short at best.

Spearing are very fond of broken Oysters and Mussels and may be easily caught in a dip-net set upon the bottom and so baited. When

they swim over the net it must be pulled up energetically, as the fishes are extremely rapid in their movements.

While scraping the bottom of a small boat to remove the barnacles, the author was once surrounded by great numbers of large Spearing attracted by this delicate food.

Stomachs of numerous individuals ranging from new-born fry to fishes more than an inch in length contained almost exclusively Amœboid Protozoa. A few Diatoms were also present. These observations illustrate how different the food of young fishes may be from that of the old ones. In one case, however, some large specimens examined on August 20th had been feeding upon some species of Sarcodina and numerous Foraminifera, resembling microscopic univalve mollusk shells.

Spearing themselves are the favourite food of Snapper Blues, or young Bluefish, which come into the inlets and along the shores in August and September and even earlier. When the Snappers first begin to run, they are very small, and the Spearing are just the right size for them. As the season advances, the Snappers increase in size each week, and likewise the Spearing increase proportionately. They grow up with the Snappers, so to speak, and thus we see the important relation of this little fish to the young Blues.

Spearing are very agile and have developed the habit of jumping from the water when pursued by the Snappers. If a Spearing be examined closely, it will be seen that its pectoral fins are capable of being tipped almost into the position of the planes of an airplane. In addition, they are quite long, and it is possible that they illustrate an early stage in the process of becoming sailing appendages. There is no reason why, in some remote time, the Spearing, which is one of the most persecuted of fishes, should not possess sailing fins similar to those of the well-known flying-fishes.

THE BLUEFISH

Pomatomus saltatrix (Linn.)

The young of the Common Bluefish (Fig. 159), known as Snappers, are among the best known of our local food fishes.

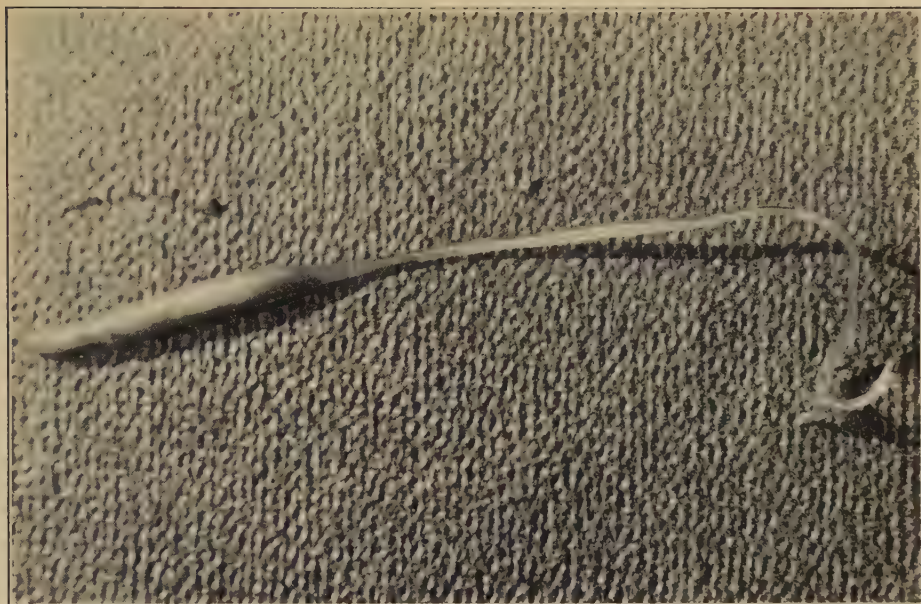


Fig. 155. The rare Copepod parasite of the Menhaden, *Lernaenicus radiatus* (Le Sueur). Twice life size.



Fig. 156. Young Eels, *Anguilla chrysopa*, as transparent as glass, as they look when they reach the local inlets after their long journey from the West Indies. Three times life size.

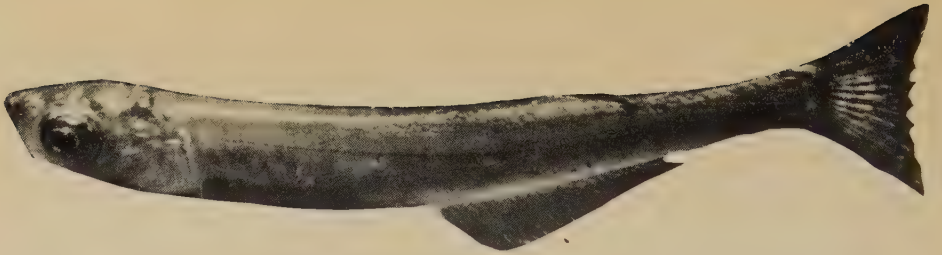


Fig. 157. The Spearing, Silverside, or "Sand Smelt," *Menidia menidia notata*. This is the common Shiner which is used for Snapper bait. It is also eaten under the name "White-bait."



Fig. 158. The Sea Horse, *Hippocampus hudsonius*. This species is occasionally taken off the Connecticut shore when the water reaches its maximum summer temperature. Somewhat enlarged.



Fig. 159. A young Bluefish or "Snapper," *Pomatomus saltatrix*. This species enters the local inlets in summer, where it is caught by eager fishermen of all ages.

In August, or earlier in certain years, they begin to run, sweeping into the inlets with the rising tides in large schools, and here they ravenously devour all the smaller fry that come within their reach. They are extremely fierce and apparently destroy more fish than they can eat, as I have observed many crushed Killies and Spearing floating in the water where Snappers occurred.

At this time, they are four or five inches in length and of a general silvery colour on the sides tinged with blues and greens. The back is bluish green and the irides a beautiful yellow.

They bite well on Spearing and Mummychogs and occasionally on Shrimps and fragments of Clams. In the stomachs of several Snappers caught in August I found the things mentioned above, with the exception of the Clams.

At Gorham's Pond, at Noroton, the Snappers rush in through the tide gate just before the water is dead high, for it is not until then that the gate opens. On some days the water near the bridge which crosses this pond is filled with the hungry fishes ravenously hunting the Spearing that abound there. Being an erratic species, however, they will be almost entirely absent in certain years.

It is an interesting fact that the Mummychogs in particular are well aware of their peril at such times as the Snappers are abundant. As the water begins to flow into the pond through the lifted gate, many of them will be seen taking shelter among bits of seaweed, or close to a floating stick or mass of refuse that has been brought in by the tide. They swim in a panicky fashion from one shelter to the next, as though knowing well the lurking danger about them.

The adult Bluefish is one of the most highly prized of our food fishes and needs no description, as it comes frequently enough into every kitchen.

HERRINGS AND ALEWIVES

The common Herring, *Clupea harengus* Linn. (Fig. 153) enter the inlets in September in thousands, where they may be seen some years in great schools, especially when the tide is nearly high. They swim grace-

fully about, flashing their beautiful silver scales in the sunlight and presenting to the close observer a great many variations in the colours upon their backs. Some individuals are a beautiful green, others blue or violet in many blending shades, while still others appear very dark green or even brown.

When removed from the water, much of this variation ceases to exist. They are very delicate fishes, and their small scales rub off almost like those of a butterfly. Indeed, it is difficult to handle one without rubbing some of them off upon one's fingers.

At this time of the year (September 22d) they measure four or five inches in length and are closely associated with the less numerous Alewife, or Branch Herring, *Pomolobus pseudoharengus* (Wilson). (Fig. 154.) They resemble the Herrings quite closely, but may be distinguished easily by the very radical differences in the heads of the two species. (Figs. 153 and 154.)

When the tide gate at Gorham's Pond opens, the Herrings and their associates pour in in great numbers and are soon imprisoned with the falling water. Here I have caught them with a big dip-net by dozens, and I am surprised that no one else, at any rate in this neighbourhood, appears to appreciate their worth as a food fish. They are small, but very delicate and quite different in flavour from the other common pan fishes.

They cannot be caught upon the hook, as they feed at this age upon small Copepods. The older fishes do not enter the inlets, and feed upon Shrimps and Copepods also.

The full-grown Herring is, of course, of vast importance as a food fish, fabulous numbers being taken every year; in fact, it is the most important of all food fishes, and it is a satisfaction to know that, as a young fish, it may be easily studied at the "back door."

SEA HORSE AND PIPEFISH

When seining for snapper bait, such as Spearing or Shiners, in the months of August, or early September, we occasionally bring up two strange fishes in the same haul that at once arrest our attention because of their peculiar bodies, which are very different from those of other familiar fishes, being covered with rough bony plates. One is long and

narrow, with a still narrower beak, tiny fins and tail, and the other has a head like a miniature pony, and a long curving body and tail.

The first of these two creatures is the Pipefish, *Syngnathus fuscus* Storer, and the second, the more familiar Sea Horse, *Hippocampus hudsonius*, De Kay (Fig. 158).

They are closely related species despite their very dissimilar outward appearance, and both occur along the coast and in Long Island Sound more frequently than is generally suspected, especially when the water has reached its maximum temperature in summer.

These two little strangers are always associated in my mind with delightful fishing days in August, and with the ever-interesting hauls of a big shore seine. There is no more fascinating sight than the landed seine, filled with brilliant Spearing, and Killies and the young Snappers that have been chasing them. Now and again the net contains a Sea Horse or Pipefish, or a Flounder or other interesting creature of the local fauna. This is as near to that greatest of all sports (seining on a tropical shore) as one may come in the North.

The Sea Horse is the only type of true fish with a prehensile tail, with which it may grasp a stem of an aquatic plant and thereby support itself in an upright position. In addition to this unusual equipment, its gills are covered by a thin skin so that they are entirely enclosed within it. Just below the horny projection on the top of the fish's head, above the gills and on each side, is a blowhole or vent, through which the water that is originally taken in at the mouth is ejected. The breathing of the Sea Horse reminds me of the working of a bellows, modified by the addition of the vent already referred to, and a device that closes the intake tube, as the bellows are compressed. It will repay the investigator to observe living Sea Horses closely in a small aquarium as they are unusually interesting fishes in every way.

All four fins upon the body proper are rapidly vibrated in swimming, but the caudal fin or tail is held motionless and is apparently useless for purposes of locomotion. Observe also that this fish swims in an upright position, which is very remarkable when we think of the usual manner in which fishes move about.

The Pipefish, on the other hand, swims straight ahead upon its belly as

fishes should. It is found in open water and also in the very shallow inlets among sea lettuce and Algæ in the summer. They are most often seen in August, and I suspect that they go there for some special purpose.

The most remarkable fact about these two fishes is that in both species the male possesses a pouch upon its belly in which the eggs are deposited by the female. The males, however, incubate the eggs in this pouch.

THE FLOUNDERS OR FLATFISHES

There are two Flounders commonly caught by the average fisherman in these waters. One is the larger Summer Flounder, *Paralichthys dentatus* (Linn.) and the other the Winter Flounder *Pseudopleuronectes americanus* (Walb.). The former is common from Cape Cod to the Carolinas and reaches a much greater weight than the latter. A larger Summer Flounder will weigh ten to fifteen pounds, whereas the largest Winter Flounder will weigh in the neighbourhood of four pounds. As they are caught locally, on hook and line, they are mostly small individuals, however.

The Summer Flounder is light olive, or olive spotted with white. There are also some white spots on some of the fins and numerous dark spots on the body also. The common Winter Flounder is dark brown, with much mottling of darker shades. In both species the colour is on the upper surface of the body.

Flounders are fishes turned sideways, because of their habitat upon the bottom of the bays and inlets. A close inspection will reveal the fact that both eyes are upon the top of the fish, and one may see how the creature has been distorted to meet its special manner of existence. In the very young fishes, this distortion does not show and the eyes are placed normally on each side of the head. Very early in its life the normal fish changes to the strange adult form, and thus it remains.

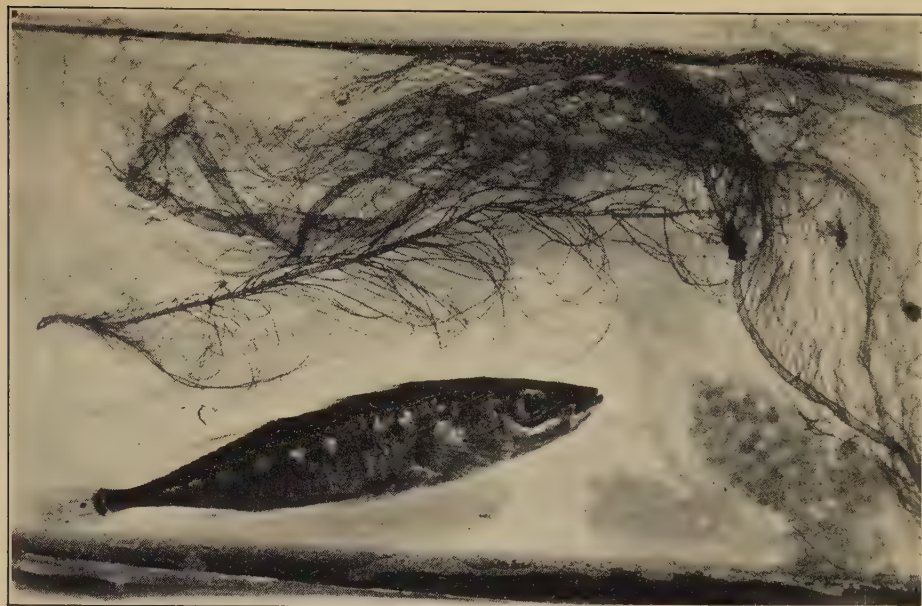


Fig. 160. Male Two-spined Stickleback, *Gasterosteus bispinosus*. The eggs are shown uncovered. Natural size.

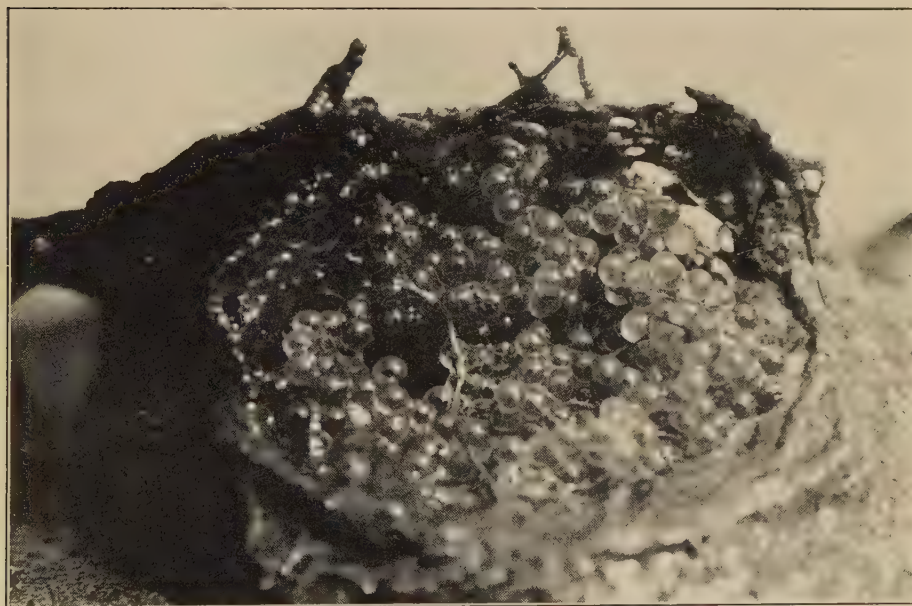


Fig. 161. The nest of a Two-spined Stickleback opened up to show the eggs. Much enlarged.



Fig. 162. New-born two-spined Sticklebacks much enlarged to show details. These little fishes are beautifully coloured and very hardy, making ideal aquarium stock. Five times life size.

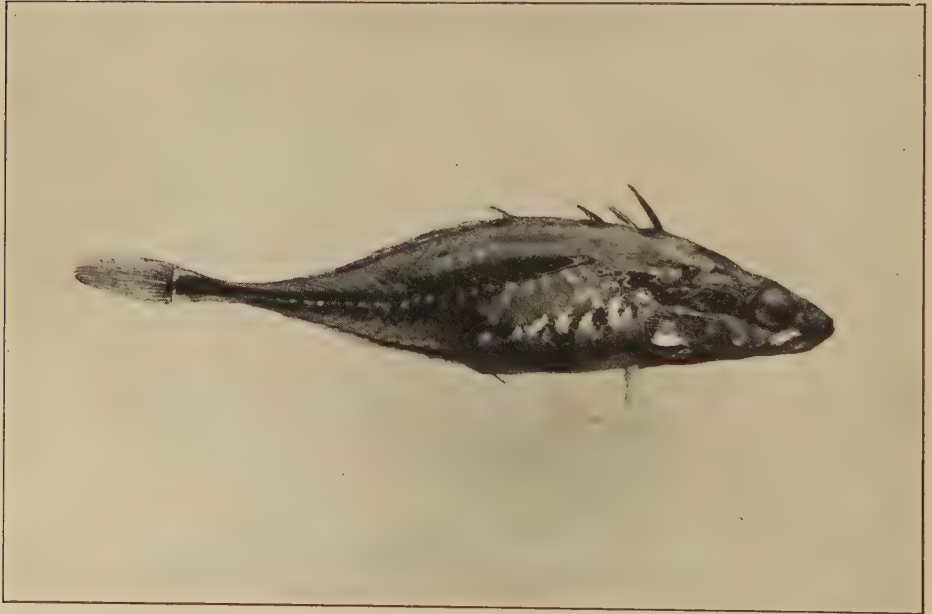


Fig. 163. Four-spined Stickleback *Apeltes quadracus*. This fish eats the eggs and young of the Two-spined species. Note the spines which may be erected and locked. Enlarged about three times.

CHAPTER XXIII

THE TWO- AND FOUR-SPINED STICKLEBACKS

Gasterosteus bispinosus (Walb.) and *Apeltes quadracus* (Mitchill)

IF ONE walks along the brackish shore lines of the inlets about the twenty-first of April, where the water is perhaps a foot or two in depth almost anywhere within the fish's range, this little Stickleback will be found. A close watch is necessary, for it is a tremendously agile creature and its back is patterned so as to be hardly visible from above. One's first sight of it will be a gray streak that travels like a flash into deeper water, but a patient and motionless watch from the edge of the land will reward the observer with much of interest.

At this time of year the fishes are nesting and spawning in soft sandy mud close to shore. They will be seen in pairs, one forever urging the other to move on, and now, if very close watch is kept, the secret of the hidden nest will be revealed. (Figs. 160 and 161.)

The male makes the nest, a more or less globular affair of bits of water weeds and threads held together with strands of a strange sticky material possessed by the species. It is almost buried in the mud with only a tiny hole in its top at the surface of the silt, by which the owner appears to recognize it. When this nest is complete, the female deposits a large mass of orange-brown spawn in it, and the pair guard it thereafter with great energy, although the male is present at the nest most of the time.

As an experiment, while the fish was in deeper water, I removed a mass of spawn and the nest, and then placed my dip-net upon the spot where the whole thing had been. In a few minutes the owner returned cautiously and after many approaches and withdrawals finally swam over the net to the approximate spot where the eggs had been resting. With a quick motion, I pulled the net up and to my surprise found the fish to be a female. It has been reported that only the male cares for the nest and my very first catch disproved this satisfactorily.

Proceeding to another nesting location, I caught a male and a female and removed their nest and eggs to a large aquarium filled with brackish water and its accompanying plants and mud. Now, within an hour, the pair had settled down to an apparently happy life, the female showing much excitement at rediscovering her eggs unharmed. She seized an end of the spawn mass in her big mouth, and then with some little force pushed the eggs down into a more compact ball. When this had been done, she proceeded to pull the water weeds and other refuse about them until the whole mass was nearly covered, just as I had seen them at first in the mud of the inlet.

The two sexes differ considerably in size and colour, the female being larger and much less gaily coloured than the male. The female measures two and a quarter inches, and the male just over two. On the cheeks of the male there is a decided salmon-coloured hue, and his sides are beautifully coloured with blue and green pigment, while his mate is more silvery, especially upon the sides and belly, and possesses a considerably greater depth owing to the ovaries. The eyes of the two fishes, both male and female, are gorgeously studded with bright blue. In addition, this species is supplied with a pair of horizontal fins like the tilting planes of an airplane, which are situated just in front of the base of the tail.

My male fish in the aquarium on the second day of his captivity settled down to a normal life, and it was intensely interesting to observe his care of the nest. At intervals of fifteen minutes or less, he would point his nose directly at the covered egg mass, and then with his pectoral fins fan them briskly with water, perhaps to aerate them, but more likely to fan away any small snails or other intruders that might damage the eggs. Once a large snail of comparatively great weight glided over the eggs while the Stickleback was away at the other side of the tank, but upon his return, he seized it viciously by one of its tentacles, lifted it bodily from the eggs and carried it some distance away. He kept bringing bits of refuse to the nest and adding them to it until it increased considerably in size. His care of the home was decidedly as carefully and thoroughly attended to as any highly developed passerine bird, and observing these actions impressed me so that I now have an entirely different feeling about fishes in general.

The eggs measure one sixteenth of an inch in diameter and cling to one another by nature of their sticky coating when deposited. They are very clear at first, and one may see the tiny developing embryo, which starts as a cell that gives rise to a group of them, and finally the little fish begins to take definite form, some eight days later.

The eggs that I studied hatched in every case fourteen days after being deposited by the parent fish. This period of incubation undoubtedly varies, however, as in other cold-blooded vertebrates, according to the temperature of the water.

The youngsters measure a quarter of an inch in length and are very active after the first day of their existence as regular fishes. They remind one more of insect larvæ at first glance, but a close inspection with a magnifying glass reveals a light amber, transparent body, studded with black pigment dots and a pair of brilliant eyes, black in the centres with surrounding circles of gold, and then the green and blue of the mature creature. These little fishes were a great delight because of their hardy nature, and because of the never-failing interest shown by their parents who kept sharp watch for intruding enemies and, as far as I could observe, never once yielded to the temptation of eating a few of their children in true fish fashion. The Stickleback will, like other species, eat its own eggs and young if confined in an aquarium without sufficient natural food, and this habit must be guarded against by the aquarist at all times. (Fig. 162.)

The natural food of this little fish, as shown by my stomach examinations with the microscope, consists chiefly of minute pink Copepods that would appear to the layman somewhat like tiny Shrimps. These are eaten in large numbers and may either be found naturally in the brackish water where Sticklebacks abound, or be washed in by the fresh-water streams that enter them. In addition to this article of diet, many Diatoms of the species *Pleurosigma attenuatum* are eaten, together with fragments of green Algæ. Diatoms are microscopic one-celled plants also belonging to the Algæ, and are found in most beautiful and characteristic forms in all waters. A rarer food of this fish consists of small winged Hemipterous insects, measuring about one eighth of an inch in length. When one stomach was opened for examination, one of these insects walked out unharmed and must have been swallowed just before the fish was

captured. Mixed with these foods, in the stomachs, are to be found tiny fragments of quartz. This is usual with fishes, batrachians, and some reptiles, and may either be swallowed accidentally with other morsels or taken purposely for grinding purposes.

Young Sticklebacks but a few days old were found to be feeding upon cells of free floating Algæ, Diatoms, and very minute granules of sand.

Closely associated with the Two-spined Stickleback is the smaller and slimmer Four-spined species, *Apeltes quadracus*. (Fig. 163.) The association is not only in habitat, but during the nesting season of the former these little intruders may be found constantly hiding near the nests of the larger ones, where they wait, if not discovered, until the emergence of the fry. From that time on it is easy picking, after the baby fishes scatter and they are easily and safely devoured. Several Four-spined Sticklebacks placed in an aquarium with the larger nesting fishes were soon dispatched and greatly mutilated in the process.

On the whole, the student will find the Two-spined form a most excellent aquarium fish if kept alone, and one that will afford endless entertainment to everybody.

CHAPTER XXIV

THE ANGLER OR FROG-FISH

Lophius piscatorius (Linn.)

OCCASIONALLY the wanderer upon the sea beaches, and even the searcher upon those quieter shores of Long Island Sound, is rewarded with an unusual prize of the deeper waters. Just how these creatures come to be washed up on the sand is something of a puzzle, for, as is often the case, no bruises or visible injuries may be seen. Even upon dissection, the flesh of a cast-up fish will often be found to be firm and hardly discoloured, and upon further search its organs will be found in a healthy condition also. Perhaps it is old age or some disease of subtle nature that cannot readily be discerned. At any rate, we find the corpses often enough, and among them on rare occasions the weird body of an Angler, one of the strangest and most interesting of fishes. (Fig. 165.)

Such a find, if made by one unacquainted with this animal, will cause considerable excitement and wonder. The news will spread rapidly, and people will flock to view the stranger from the depths with its terrible mouth and horrid eyes. The press soon makes a story of it and many wild tales are related before someone who knows the creature comes along to name the beast and explain all about it.

A glance at the Angler tells us at once that the fish is a bottom-loving creature. Its whole make-up points to this, and it should be mentioned here that a close inspection of almost any strange animal will often give clues as to its mode of existence. For instance, the body of the Angler is flat and broad, its upper surface being mottled and camouflaged like the bottom of the Sound. The under surface is unclouded by pigment and supplied with foot-like fins. Its mouth is wide and trap-like, and above it dangle two curved appendages which may act as lure to other fishes when the Angler's mouth is open.

All these things declare that the species plods about the bottom among

sand, mud, and seaweeds. When hungry, it lies motionless, depending upon its camouflaged body for invisibility. Its great mouth is held wide and its "bait" dangles in front of the trap until an unsuspecting flounder swims near enough to be captured.

There is a report that one of these Anglers, when dissected, was found to contain the bodies of ducks. This story is hard to believe and is probably fictitious, as it is extremely unlikely that the fish would swim to the surface in quest of game! It is, however, possible that ducks might have been captured while feeding upon the bottom.

The teeth of the Angler are hinged and in rows which tip backward. A victim thus finds it easy to enter the trap but impossible to escape. In the bottom of its throat are numerous spike-like processes. These are very tough and doubtless make the stomachward passage doubly irksome for the captured prey.

The name Frog-fish is certainly not inappropriate, for the creature does resemble a huge, flattened frog in the late tadpole stage. The tongue and the interior of the mouth are particularly frog-like except for the teeth. In addition to these amphibian characters, its ventral fins have evolved into remarkably foot-like appendages. (Fig. 166.) The cartilage rays within them, which make up the fin or "foot" skeletons, have divided into five of these rays, but each will be seen by the photograph to be made up of numerous other rays that have become fused. These five "bones" support the five blunt "toes" into which the ventral fins have evolved. (Fig. 164.)

The mode of existence causes great modifications in the appendages of all kinds of animals. In the seal, for instance, we see the mammal feet changed into strong swimming flippers or fins, while in the Angler we have the ordinary fins of other fishes so altered that they have almost become feet!

An Angler that came ashore at Sound Beach, Connecticut, January 13, 1923, which was closely studied by the author, measured three feet one inch in length and thirteen inches in width at its widest part. The mouth was ten inches wide and five inches high when wide open, and the total thickness of the body at its heaviest point was only three inches! What stranger dimensions could a fish have?

Upon dissecting this specimen I found its stomach to contain consider-

able sand and mud and fragments of seaweeds. In addition, and the *pièce de résistance* of the meal so lately eaten, was a partly digested flounder ten inches in length.

As is often the case with fishes, numerous parasitic round worms were also found, but these were in clusters around the outside of the creature's stomach instead of within it. There were such numbers of them that they may have had something to do with the death of this individual.

The adaptations of fishes in general are very remarkable. There is the Four-eyed, South American species, a Killy-fish that has developed optical equipment, half of which enables it to see above the water, while the other half is suited to seeing below the surface. This animal is therefore enabled to see its enemies in two different mediums.

I have seen these fishes in considerable numbers at the edges of the great tropical rivers. Here they allow themselves to be tossed back and forth by the wavelets, living a life that would appear to be that of an amphibian of the early days.

There are the tiny and numerous Rivulus fishes that live in every pool and jungle stream. So often do their pools dry up that the fishes have become adapted to living many days out of water. If one pool dries up, they flip themselves about over the damp leaves until another one is located, a jungle leaf that has caught some rain being sufficient to revive them for the next hop, and so on until a real pool is found.

And so we might mention countless adaptations, but in the Angler we have a wonderful case right at home.

CHAPTER XXV

MUMMYCHOG OR KILLYFISH

Fundulus heteroclictus macrolepidotus (Walb.)

AN ENORMOUSLY abundant species (Figs. 168 and 169) in salt and brackish water. They congregate in spring in tremendous numbers along the shores of the inlets to spawn. At this time they form one of the chief foods for Herons, Kingfishers, and Gulls, who find easy pickings wherever the schools happen to be.

Toward spawning time, the males take on very beautiful speckled patterns. They become very dark, and the fins become tipped with brilliant yellow, and more or less checkered patches of black and white become strikingly noticeable upon the dorsal and anal fins. The females are very pale and swollen with spawn.

Spawning is going on in full by June 30th, the eggs being deposited loosely upon the mud at the base of the stems of grasses, and in such a position that they are uncovered for many hours each day, when the tide recedes, but they are never so placed as to become dry.

The eggs measure two millimetres in diameter and are brownish yellow and transparent, appearing exactly like the Stickleback's eggs except in colour, and the gold-rimmed eyes of the fry may be easily seen through the spheres. Spawning commences considerably earlier than June 30th, as young fishes three fourths of an inch in length are common at that time. It is, however, the main breeding season of the species. Eggs well advanced in incubation make splendid objects to study under the microscope, as the actual circulation of the embryo may be seen to good advantage without disturbing the egg in any way.

The male's courtship consists of very energetic gyrations about the female and often ends in his rising to the surface, where, turning upon his side, he flips along in and out of the water like a stone that a boy skims



Fig. 164. Cartilage "skeleton" of the "foot" of the Angler, showing the rays that support the apparent "toes."

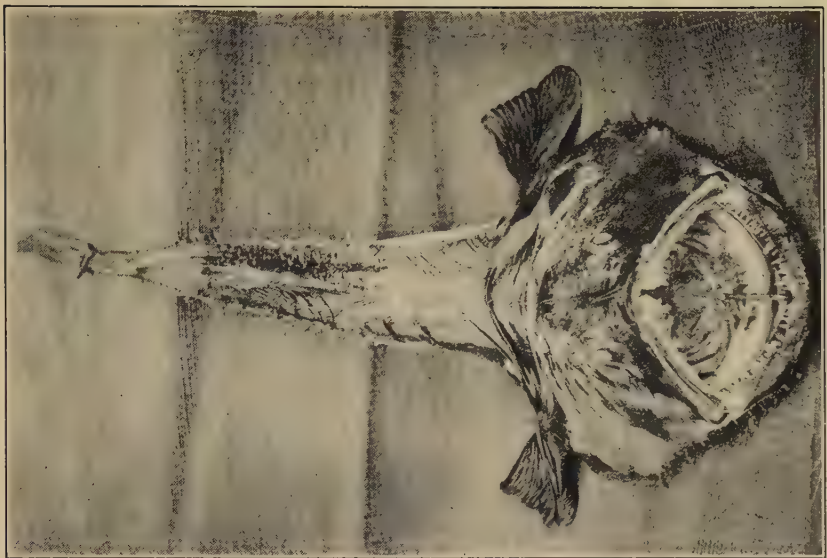


Fig. 165. The Angler or Frog-Fish, *Lophius piscatorius*. Much reduced. The fish is more than three feet in length.



Fig. 166. Under surface of the Angler, showing the foot-like appendages.



Fig. 167. Foot-like fin of the Angler, showing "fingers" supported by cartilage rays.
About one half life size.

and causes to ricochet. Competition is so great, however, that it is doubtful whether the female sees this accomplished by any particular suitor.

At the places where spawning is in progress one may observe the water at the edge of the land as though it were boiling. Close inspection reveals that the females, with their backs almost protruding and in very shallow water, are dropping their eggs, while the males rush up and with a quivering motion eject their milt over them. All is commotion, and so occupied are the fishes that one may watch the whole thing without frightening them away.

Mummychogs are easy to keep in an aquarium, requiring little care. They will feed readily upon dried ground Shrimp or Earthworms or even bread crumbs.

To start a salt-water aquarium, place a few inches of beach sand in the tank and fill it with salt water and plenty of the common green sea lettuce which may be found in flat, emerald leaves in any inlet between June and November. This plant is the best for such an aquarium, and about one third of the water space should be filled with it. Allow one gallon of water to every inch of fish.

The spermatozoa, or milt, may be obtained by squeezing the fish at each side of the anus. A drop of milky fluid will be obtained, which contains millions of very active cells which are well worthy of observing under the microscope.

The new-born fry measure six millimetres in length and are also splendid objects for observation under low-power lenses, as the entire body circulation may be observed, the streams of corpuscles, clearly visible, bathing every part of the fish, not excepting the tip of its tiny tail. One sees this stream of life and realizes with wonder and reverence that the very same thing, in the same manner, is going on within one's self.

Another reason why the new-born Mummychogs are so satisfactory for general work is that they are the reverse of the Sand Smelts and no end of shock is necessary to injure them. They will live for a long time in a drop of water under the microscope in a brilliant light from the mirror, and will swim off happily enough when returned to the aquarium by means of a medicine dropper.

The food of the fry consists of a few Copepods, Diatoms in profusion, and a few tiny, shelled creatures like Foraminifera such as the Truncatulina. The fluid from their stomachs is also filled with minute whirling organisms too small to identify, and many parasitic flat worms.

The food of the mature fish is quite varied. A specimen examined May 16th which was taken in a brackish inlet had eaten the organisms listed below:

Eggs of Stickleback	2
Amœboid Protozoa	15
Algæ (fragments)	10
Remains of Wheel Animalcules	15
Ostracoda	1
Flatworms (Live parasites)	6

Mummychogs also eat Shrimps, and minute Clams, and insects.

Very fat individuals (adults) taken on October 15th, in the same inlet, at high water, had their stomachs distended with chains of Algæ, exactly like the fresh-water species, *Hormidium nitenz* Meneghini, while smaller fishes contained large numbers of Pleurosigma and other Diatoms, besides many tiny bits of mineral matter.

On every high tide the Mummychogs follow the rising water, keeping always at its edge. They come in great numbers, and as the tide floods the salt meadows they sweep over it, sometimes being hardly covered, and here they feed on numerous land organisms that are trapped among the grasses. At such times, usually near full moon, the meadow back of my house is often submerged, and swarms of fishes just beneath the surface give the whole water's edge the appearance of a boiling lake, while their continual flapping and leaping half out of their medium only adds to the strange illusion.

In winter the Mummychogs are more or less active, according to the temperature. They come to the edges of the inlets where the ice is thinnest or where it has partly melted away. Here they take advantage of what warmth the sun offers and are often caught at this time by wintering Night Herons.

Algæ appears to be the chief winter food, but I find that the fishes do not distend their stomachs with it as they do in the fall. Numerous minute Diatoms are also present in the stomachs of winter individuals. They are probably eaten with the Algæ, but many of them are still capable of motion.

CHAPTER XXVI

SOME COMMON FISHES OF FRESH WATER

OUR Eastern fresh-water ponds and streams are not very well populated with species of fishes, but individuals are abundant and are easily studied at home, and there is much for the patient investigator to record. I have room in this book to tell only a little about each common variety, and the field is open to anyone who will concentrate his efforts upon the subject. A published study of the habits and interrelations of the fishes and other creatures of any local pond or stream would be a valuable addition to piscatory literature.

Exclusive of those numerous fishes collectively called Minnows, we have but ten common varieties to work with. Altogether there are but sixteen easily found fishes, but this number is exclusive of several small Minnows which are left out of this book because of the great difficulty of distinguishing the different species. The family of Minnows is one of the most difficult in all the realm of zoology.

Five of our fresh-water fishes listed below belong to the Minnows and the family is known as the Cyprinidæ. They are the Common Shiner, the Hornyhead, the Fallfish, the Common Chub, and the Black-nosed Dace. The Common Shiner is found in ponds or streams, but I have never collected any of the other four from still water. These four are lovers of the swift cold brooks and rivers.

The commoner fresh-water fishes found within the territory of this book are as follows:

- | | |
|-----------------------|------------------|
| 1 Black-nosed Dace. | 6 Common Sucker. |
| 2 Fresh-water Killy. | 7 Yellow Perch. |
| 3 Tessellated Darter. | 8 Fallfish. |
| 4 Redfin or Shiner. | 9 Hornyhead. |
| 5 Black Bullhead. | 10 Common Chub. |

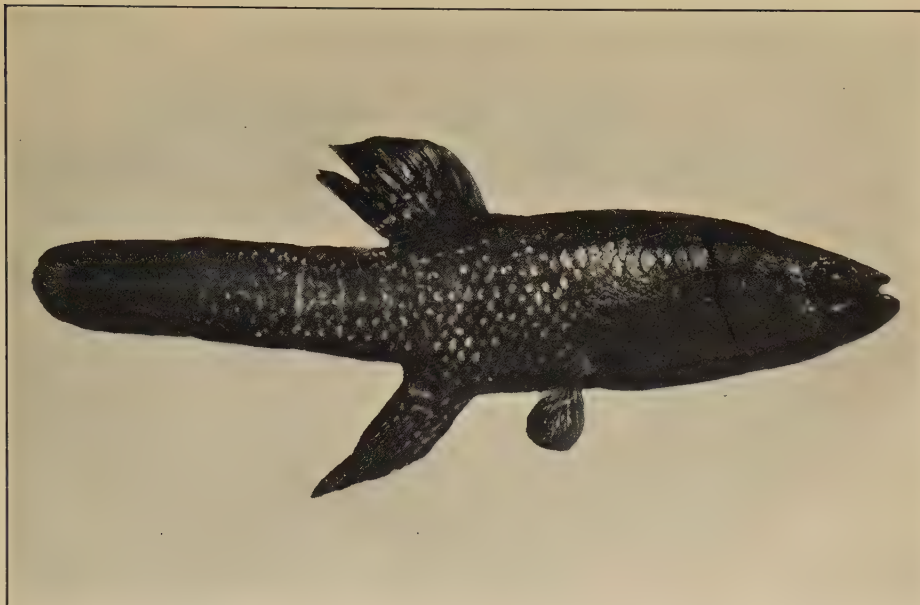


Fig. 168. Mummychog, *Fundulus heteroclictus macrolepidotus*. This is a male in breeding dress. Natural size.

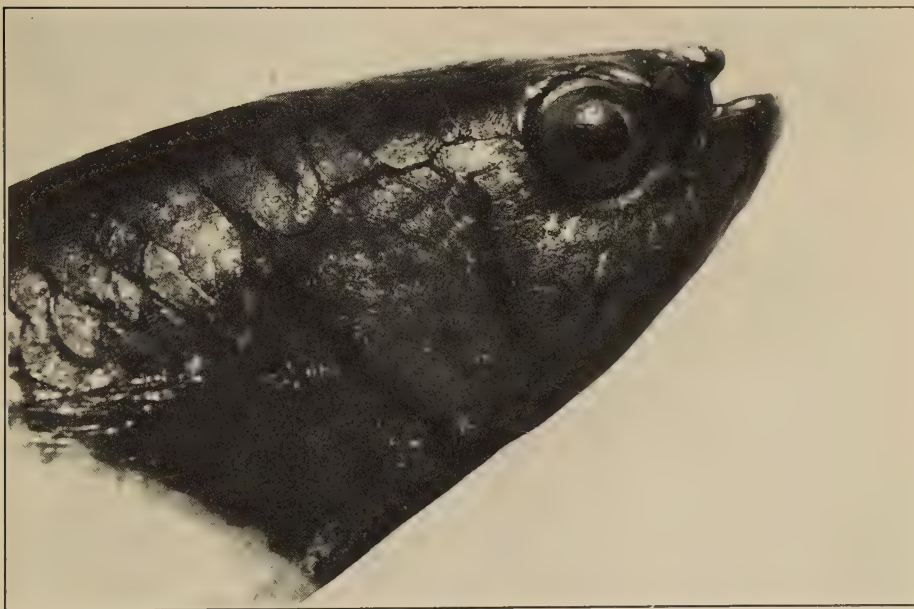


Fig. 169. A greatly enlarged head of a Mummychog, showing the scales like plates of armour.

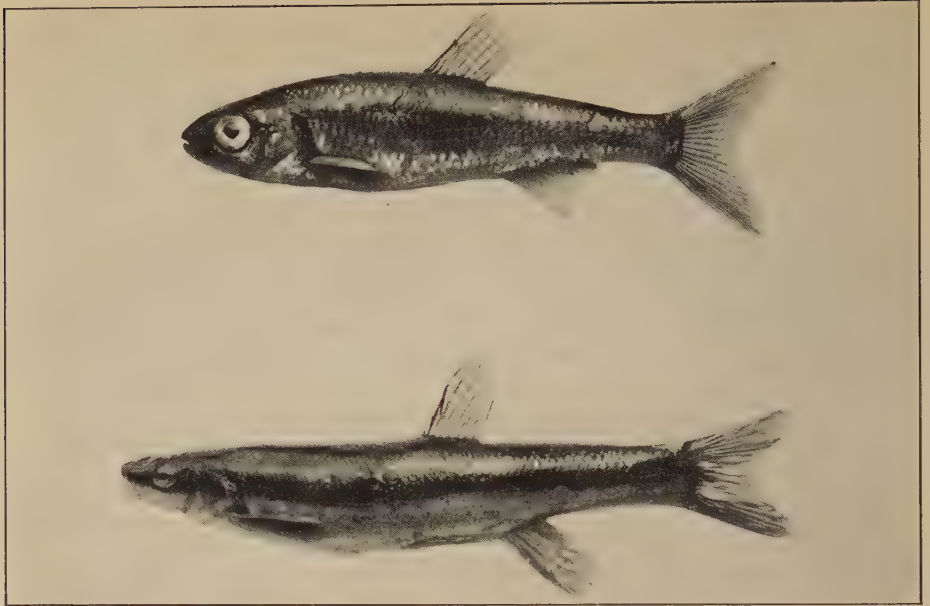


Fig. 170. Upper: Redfin or Shiner, *Notropis cornutus*, immature; lower: Black-nosed Dace, *Rhinichthys atronasus*. Life size.

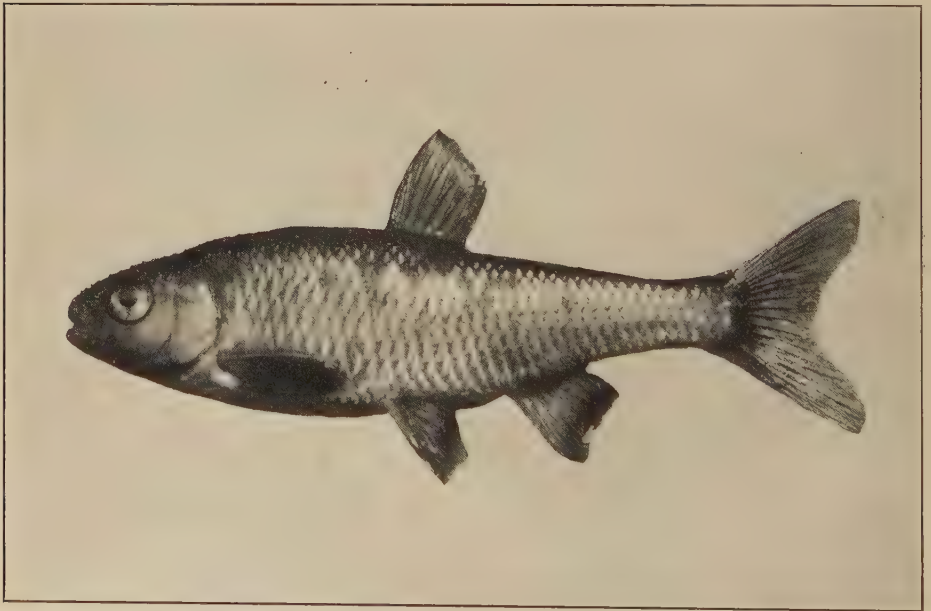


Fig. 171. Hornyhead, *Hybopsis kentuckiensis*, male, from the Mianus River, May 19, 1925. Two thirds life size.

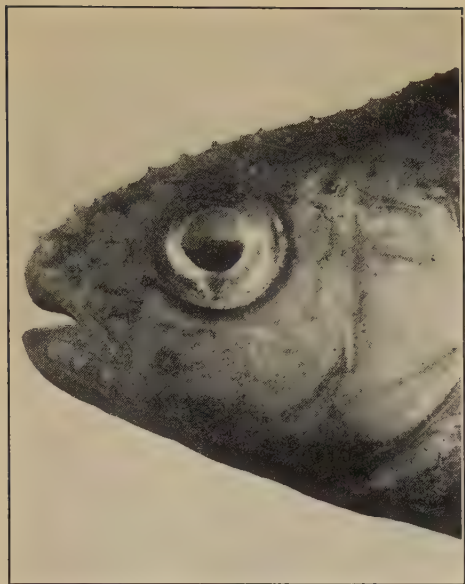


Fig. 172. Head of Hornyhead showing crown of tubercles. Mianus River, May 19, 1925. Considerably enlarged.

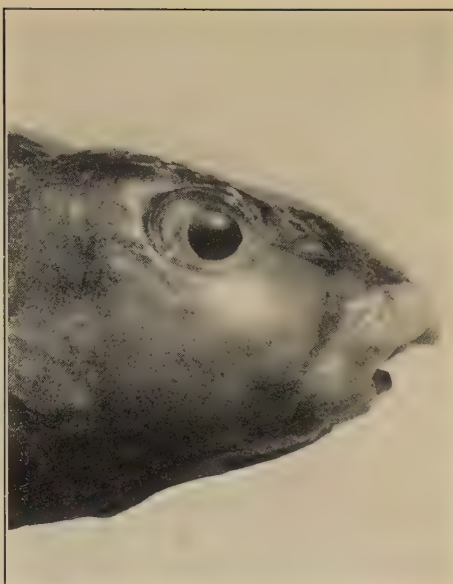


Fig. 173. The head of the Common Sucker, *Catostomus commersonii*. Note the characteristic mouth. Life size.



Fig. 174. Eastern Brook Trout, *Salvelinus fontinalis*, young, enlarged five times. April 22, 1925, showing pigment dots forming the bands, which are typical of young trout. These dots are suggestive of the actual composition of a half-tone illustration, which is also made up of dots. They are plainly revealed because of the magnification.



Fig. 175. The Tessellated Darter, *Boleosoma nigrum olmstedii* (Storer)
Common in clean brooks and streams. Twice life size.



Fig. 176. Spawn of Small-mouthed Black Bass on stones. Enlarged about two and one
half times. Mianus River, May 19, 1925.

- | | |
|------------------------|------------------------------|
| 11 Red-breasted Bream. | 14 Small-mouthed Black Bass. |
| 12 Common Sunfish. | 15 Large-mouthed Black Bass. |
| 13 Brook Trout. | 16 Pickerel. |

THE BLACK BULLHEAD

Ameiurus melas (Rafinesque)

This is the smallest of our Bullheads and the commonest. It may reach a length of ten inches, but I have never found one as large as this, and the great majority are under six inches. It may be distinguished from all other local fishes found in ponds and streams by its barbels or "whiskers." In colour it is black or brown with a very smooth skin. The anal fin (the fin nearest the tail on the under side) is conspicuous for its light rays and dark-coloured membranes. This and its smaller size distinguish this fish from the very similar Common Bullhead, *A. nebulosus* (Rafinesque).

The Black Bullhead is common in small mud ponds and less so in the clearer streams. It is fond of weeds and lily-grown bodies of water, where it feeds sluggishly among the vegetation. Stomach examinations of numerous small specimens found on July 11th revealed the fact that the fishes had been feeding almost exclusively upon those strange and minute crustaceans known as *Daphnia* or Water Fleas. Their stomachs were crammed with these organisms.

There is a small pond near Long Ridge, Connecticut, that is inhabited by very small examples of this species. This pond is tiny itself, shallow, and with a thick mud bottom. It sometimes dries up in summer, and it has always been a puzzle to me how these fishes originally arrived in it.

Few of us have not fished for Bullheads, and they are not bad eating, after all. I have taken them in the Mianus River on liver for bait, and these individuals were about six inches in length.

The Common Bullhead, which doubtless is to be found in this vicinity, although I have never had any experience with it, grows to a much larger size, according to some authorities up to fifteen inches, and there is one example of an individual weighing seven pounds!

Bullheads spawn in the spring, and sometimes the weird little fry

may be seen following the old fish about. Whether this is coincidence or habit I am unable to state, but it is one of the most interesting and beautiful sights that I have been fortunate enough to witness.

THE REDFIN OR SHINER

Notropis cornutus (Mitchill)

The Shiner is the best known of the Minnows, at least to the boy who has been raised in the territory covered by this book, and there are few of us who cannot look back upon those happy days when, with the tiniest of hooks or a big dip-net, we lifted the living bits of silver from the cool murmur of the brook and feasted our eyes upon our prizes.

I have found these fishes in schools in small brooks, where they love to congregate in the deeper parts often in the shadow of a boulder or a bridge above. At other times I have caught considerable numbers of them from perfectly still ponds such as those, often met with hereabouts, that are used for ice cutting.

The Redfin reaches a length of five inches and has a deep but not thick body and a very small head. The scales are large and the irides pale yellowish. The pectoral and ventral fins are tinged with orange. The back is greenish, head brown on top, and the sides of the body shine silvery white. Although they reach five inches in length, the vast majority of them are considerably smaller specimens. (Fig. 170.)

A pond which swarmed with Redfins lay in the valley below Keeler's Hill in Stamford. This has since been filled in to make room for a land development, and the waters that swarmed with interesting life are no more.

The food of the Shiner consists of both animal and vegetable matter. Their stomachs contain a few Volvox, quantities of minute Diatoms, green Filamentous Algæ, and in season great numbers of the Common Diatom, *Charicium longipes* (Rabenhorst). Animal food taken consists of Flagellate Protozoa and small water beetles. They will of course bite on worms and other baits. Most of the stomachs examined also contained considerable mineral matter.

The breeding season is in June, and females swollen with eggs may be found about the first week in that month.

BLACK-NOSED DACE

Rhinichthys atronasus (Mitchill)

This little fish has an oblong tapering body of cylindrical shape and a deeply forked tail. It seldom exceeds three inches in length. The under jaw is shortest, giving the head a blunt appearance, and the nostrils are large and oval. The back is greenish and the abdomen silvery white. A broad blackish band from the nose passes through the eyes and runs clear to the tail. The pectoral fins are tinged with more or less brilliant orange. (Fig. 170.)

This Dace is common in clear running brooks and streams—whether large or small seems to matter not. I have found it numerous in tiny brooklets running through roadside culverts and in the larger and deeper streams such as the Mianus.

In June the fry appear and soon afterward are exactly like the older fishes in colour and pattern.

Stomach examinations of the fry show that they consume large quantities of Diatoms and Amœboid Protozoa of the Diffugia type, just as the young common Suckers do. In addition to this diet, many minute dipterous midge larvæ and adults are taken.

In the older fish I found the diet to be almost exclusively animal matter, consisting of flies and other insects and a few small spiders!

HORNYHEAD

Hybopsis kentuckiensis (Rafinesque)

This is the most beautiful of our Minnows. (Figs. 171 and 172.) In the breeding season, which commences about the 15th of May, the males are gorgeously tinted, and at this time the fishes will be found in small schools about the edges of streams, where they swim about in the sunlight, following the females back and forth through the water.

They reach a length of ten inches or more, but most of them are little more than six inches. The body is stout and bluish olive above, with greenish tints. The sides show much bright green and coppery reflections. In full-grown specimens there is a curved, dark-coloured bar behind the opercle. Belly whitish with no silvery sheen. In spring the belly of the

males is rosy. Fins all more or less coloured with rose or orange. There is a red or rosy spot on each side of the head in the males. The top of the head is covered with large tubercles forming a rasp-like crown. This and the colouring is so conspicuous in the breeding season as readily to identify this species in the territory covered by this book. In the young there is a dark spot on the tail.

The species bites well on worms and is quite gamey for its size. It is used as bait for larger fishes, but perhaps serves its best purpose by supplying a good fish for the young angler.

FALLFISH

Semotilus corporalis (Mitchill)

This species is found commonly in the larger streams such as the Mianus and Rippowam. In the latter stream it is much less common than in the former, doubtless because of its shallower and more sluggish nature. The Fallfish likes deep pools or the vicinity of small falls. If the stream offers both of these attractions so that the fishes may course back and forth, conditions are ideal for this species.

It is the largest of our Minnows locally, growing to fifteen inches. Its body is long and rather robust, with large scales. The colour is steely blue above with brilliant silvery sides and belly. The fins of the male and the belly are tinged with rose in the breeding season. There are no spots on the fins except tiny specks, which are caused by parasites.

In late May the fishes may be taken with spawn in their bellies, and this is apparently deposited near the edge of the stream in sandy situations. At this time some of the males are beautifully tinted, and there is much rivalry among them.

The Fallfish is easily caught with a small hook well covered with worms, and will afford no little sport in the early part of the year when the water is cold.

Thoreau states that the species is "soft and tastes like brown paper salted." Never having eaten this delicacy, I am really no fit person to criticise so eminent an authority, but Thoreau must have had a bitter taste in his mouth when he made that statement. In the spring, when the water is cold, there is nothing better than a mess of Fallfish, freshly

caught from the stream and cooked by its side in a pan of deep butter. The Fallfish is one of the most delicate and delicious of fresh-water species.

Young Fallfish feed upon Diatoms and tiny vegetable forms almost exclusively, while the old ones take an almost exclusive insect and animal diet. In their stomachs I found the heads and legs and wings of flies and the bodies of aquatic insect larvæ.

COMMON CHUB

Semotilus atromaculatus (Mitchill)

This species is very much like the former, but there is always a black spot at the anterior base of the dorsal fin (the fin on the top of the body.) The colour is more dusky with less blue upon the back, and there is an indistinct dark band, which is conspicuous in the young but absent in mature fishes. The belly is white, turning rosy in the males in spring. The young fishes also have a black spot upon the tail.

The Chub may reach ten inches in length, but in my experience this is rare. Most of them are much smaller. They inhabit streams and small brooks of all kinds and are very common.

Their habits are much like those of the Fallfish, except that they are content in much smaller streams and in shallower water.

As is the case with so many fresh-water species, the young feed on minute Protozoa and Diatoms, while the older fishes subsist upon aquatic insects, flies and insects that come to the surface of the stream to deposit their eggs.

I never had realized, until I came to study our local fresh-water fishes, what an important part the microscopic Protozoa, the Diatoms, and other minute organisms played in the lives of young fishes. In the economy of the pond and stream they are of tremendous importance.

FRESH-WATER KILLYFISH

Fundulus diaphanus (Le Sueur)

This beautiful little species resembles the big salt-water Killy in general characteristics, but it is much smaller and of a slimmer build. It is brilliantly opalescent, the colours being very bright and beautiful. The sides are marked by numerous dark bars. The general colour of this fish

may be light or dark according to its environment; thus specimens taken from a pond in the open will be light, while others caught in a deeply shaded brook will be much darker.

I associate this Killie in my mind with the Common Sunfish because it is so often found about their nests. For some reason that I have not definitely decided, the Killies are certainly attracted to the Sunfish's nest. They act as if it were partly their property. I have observed them actually aiding in the protection of such nests, and it may be that they also deposit their eggs in the sand, which is cleaned of mud by the larger species for its own eggs, and the association has become mutually beneficial. Again it may be that the Killie prefers a sandy spot in which to dwell, for in my experience those found in brooks have always picked a sandy bottom.

This fish is sparsely distributed in the territory covered by this book, and I have found them in only two places. One was Keeler's Pond on the Boston Post Road between Sound Beach and Stamford (since filled in) and the other was a small brook in Glenbrook. The Killies inhabited this brook until about 1908, but they are now extinct in this bit of water. This particular brook ran into the Sound about four miles from where I used to collect the Killies. Since these two places have been destroyed, I have been unable to locate a pond in which they are still to be found, although such a place must certainly exist.

COMMON SUCKER

Catostomus commersonii (Lacépède)

The Common Suckers may be identified at once by their strange sucking mouth (Fig. 173), which is situated under the forward portion of the head, rather than at the extreme front as in other local fishes. In colour they are olivaceous, but in spring a rosy hue suffuses the males. It possesses a rather heavy, stout body, upon which the scales are small, becoming crowded near the head. Young specimens are brown and show much mottling of darker colours. They move with great rapidity, and a mere streak is all one sees as they dart past.

The species is common locally and is found over a wide range, in brooks, ponds, and streams. Although it reaches a length of fifteen inches,

its size appears to be controlled to some extent by the size of the stream which is inhabited. Small specimens are found more abundantly in small brooks and large individuals in larger streams.

In spring (early May) Suckers run up the smaller streams and brooks to spawn, and about the first week in July young fishes an inch in length become plentiful. The big fellows, if taken early from cold water, are very good eating, but later lose their flavour, becoming flat or muddy in taste. They cannot be caught with hook and line owing to their peculiar sucking mouth, which is not well fitted for grasping live bait.

Stomach examinations of fishes an inch long, taken in July, showed them to be feeding upon enormous quantities of Diatoms of numerous species and of comparatively large size. There were also a few small water mites (Hydracarina) and quantities of Amœboid Protozoa, such as the Diffugia forms in their beautiful microscopic cases formed of tiny fragments of mineral matter. In addition to these items were a few parasitic worms and numerous other microscopic objects.

To the student of fresh-water biology who may have experienced difficulty in finding desirable material of a microscopic nature, let me advise the capture of a few young Suckers in July, when they are about an inch in length. If he will kill these in 20 per cent. ethyl alcohol and later gently squeeze the contents of their stomachs and intestines upon a glass slide and tease this out in a drop of water before applying the cover glass, he will have enough material to work with for some time to come, and material of an exquisite nature.

TESSELLATED DARTER

Boleosoma nigrum olmstedii (Storer)

A small, active darting fish (Fig. 175), protectively coloured to match the sand and pebbles in the beds of swiftly flowing brooks and streams. It is olive-brown with black markings along the back and sides and possesses a black line from the eye, directed forward. The rays of the fins are closely spotted or dotted with black. Length, two and a half inches.

This species is common in clean sandy brooks and streams whose flow is fresh throughout the year. It remains upon the bottom, moving in jerks. Its coloration is so protective that it does not move, as a rule,

until almost touched. The simplest method of catching it is to walk slowly up the brook, watching closely until one is spotted. A net of bolting cloth is then lowered in front or behind the fish, which is then frightened into the trap by a stick lowered into the water. These Darters are commoner and more easily found in May and June than later in the year.

The breeding season is in May, and at this time the males sometimes follow the females about from place to place, awaiting the spawning. Females with well-formed eggs and eggs ready to be expelled may be secured by May 19th.

Darters feed chiefly upon aquatic larvæ, stomach examinations revealing mostly Hydropsychids, and young Caddice Worms of other kinds. An occasional Ostracoda is also eaten, this being a representative of a very common family of tiny, bean-shaped aquatic creatures with limy bivalve shells which are hinged along the dorsal margin. They enter into the menu of many fishes in both fresh and salt waters. No particles of mineral matter were found in the stomachs of this species.

As is so often the case, numerous parasitic flatworms attack these fishes, lodging in the intestines.

EASTERN BROOK TROUT

Salvelinus fontinalis (Mitchill)

The growing scarcity of the Brook Trout is one of the saddest stories that must be recorded. Owing to continual and senseless persecution by fishermen—not sportsmen, for they are respecters of wild life—we have but a remnant of the former Trout army. Except for young specimens, this fish is never common here, and it is only on rare occasions that a really large Trout is taken. In spite of all this, it is remarkable to record that in the spring of 1926 a Trout measuring more than fifteen inches in length was caught from the Silvermine River!

I know also of certain tiny streams, brooklets really, that all but dry up in summer, that are still inhabited by considerable numbers of small Trout. I found them once in a small school from which individuals could be caught with a dip-net. Crossing this stream, which is ten feet wide, is an old stone bridge under which one may just pass if stooping over. Here the water is perhaps ten inches deep in summer when other places

are drying up. Dwelling beneath this bridge since the summer of 1923 are a number of Trout ranging from four to ten inches in length. They have been overlooked, fortunately, owing to the insignificance of the brook in which they live.

Trout spawn in the fall during October and November, working well up the streams to trickling brooklets with sandy or gravelly beds. The eggs lie over until the water warms in the spring and, by the end of April, fishes thirty millimetres long may be found.

These youngsters are at once Trout, even to the inexperienced eye, possessing all the lines and looks of mature fishes, but in respect to colour they are quite different and extremely variable. They are always marked by a number of dark bands, however, which are made up of tiny dots of black pigment (Fig. 174). The brilliant spots of the old fish are not present at this time.

The food of these youngsters consists of Plecoptera in the larval form, and other insects. Three individuals measuring three and four inches examined in midsummer had been feeding upon small black flies, fragments of minute water beetles, larger aquatic insect larvæ, and a few Flagellate Protozoa resembling rubber balls of microscopic proportions with long hair-like tails protruding from them.

The diet of the older Trout consists of beetles, worms, various kinds of flies, and the Neuropteroid insects common about the waters inhabited.

It is an interesting fact that Trout occasionally descend to salt or brackish water. I caught one measuring twelve inches in Gorham's Pond at Noroton, Connecticut, on August 11, 1925, in the most saline part of this body of water, close to the tide gate. It was in perfect condition and brilliant in colour, but sluggish. This specimen evidently had come down one of the brooks that empty into this pond. Its stomach was entirely empty, and it had not been able to find food in its unnatural environment.

COMMON PICKEREL

Esox reticulatus (Le Sueur)

There is no fish in the local waters that could be confused with the Pickerel. Its green colour and golden sheen, its sharply sloping head and

elongate body at once distinguish it. (The common Pike, *Esox lucius*, is spotted with white.)

Pickerel are found in lakes and large ponds and occasionally in the streams where they feed voraciously upon frogs and fish. Ponds inhabited by lilies are favourite places of the Pickerel, where they lie hidden, but ready to dart out upon unsuspecting victims.

Pickerel reach a length of two feet in some cases and are very good food fishes. They are caught by trolling or by skittering with a frog or piece of fish for bait.

The species ranges over a wide territory, being found from Maine to Florida and west to Arkansas, Louisiana, and Tennessee.

Small but beautiful individuals of this species may be found in the late summer in brooks with a sandy bottom. They are easy to see at this time because of the low water and their sharply mottled appearance from above. Being long and narrow, they are easily separated from any other fish of our local streams.

RED-BREASTED BREAM

Lepomis auritus (Linn.)

Our two common species of Sunfishes are usually confused, or at least considered as identical, by the casual observer, but there is considerable difference, and the easiest method of separating them is by the posterior portion of the gill covers (opercular flaps). In the present species this is extended into a long flap which lies close to the body and is black, with a paler lower margin. In the Common Sunfish, or "Pumpkin-seed," this flap is short and of a different colour. The belly of the Bream is more red than that of the other species, often being a beautiful orange-red. The brilliant reds and blues and yellows of these fishes separate them easily from all other local fresh-water species.

The Bream inhabits rivers and streams and is exceedingly common over a range extending from Maine to Louisiana.

As a pan fish I personally cannot recommend Bream although they are much relished by some people. They are extremely bony and difficult to eat, but being easily caught and of fair size (up to eight inches), are sought after by boys everywhere.

The Red-breasted Bream nests very commonly in the Mianus River, and appears to be the only one of the Sunfishes that does. Large numbers of nests with fresh or nearly fresh spawn may be found by July 1st. This is probably the chief spawning time, as numerous examinations made at the streams show most of the females to be loaded with eggs at this date. The nest consists of a more or less circular spot from which the male fish fans away all dirt and débris with his fins. The female then deposits the spawn upon the pebbles and sand, to which they adhere. If one looks into a nest, there appear to be no eggs in it, but if the sand is scooped up in one's palms, the stones will be found studded with yellow eggs which are thus protectively coloured.

The male fish guards the nest and drives away all intruders until the the young fishes appear.

COMMON SUNFISH

Eupomotis gibbosus (Linn.)

The best known among our fresh-water fishes. This is the boy's own fish and what boy has not waited eagerly for the end of school or cut it altogether for a day, to make haste to the favourite fishing hole for a string of Pumpkin-seeds? Who in youth has not walked proudly home with a dozen or more of these trophies of childhood, shrivelled, sunken-eyed, but as precious as a creel of Trout to the experienced angler? The Sunfish, I am sure, stands for happy days and fond memories in the mind of many a man.

The name Yellow-belly, so often applied to this species, although appropriate, has its drawbacks for the reason that the other Sunfish, or Bream, *Lepomis auritus*, is also more or less yellow upon its under side. The common Sunfish, however, may always be distinguished from its near-relative by the flap that extends from the posterior part of the gill covers (opercular flaps). In the present species it is short and bears a bright scarlet mark, whereas in the Bream it is much longer and black.

In late May and early June these Sunfishes fan away the débris at the edge of the pond or in a rather quiet stream, constructing a more or less circular, flat, inverted cone, with a sandy or stony bottom. This is the nest, and here the eggs are deposited and afterward faithfully guarded

by the male fish, until the young are hatched by the gentle rays of the sun.

The eggs are amber-coloured and are attached to small stones and sand grains. These nests are often inhabited by Fresh-water Killyfishes. They may possibly spawn in them under the protection of the larger fishes, helping to guard the nests in return.

The Common Sunfish is found over a wide range, from Maine to the Great Lakes and southward, east of the Alleghanies to Florida. It is found in clear streams, brooks, and ponds, more commonly in the latter.

SMALL-MOUTHED BLACK BASS

Micropterus dolomieu (Lacépède)

A common and splendid game fish found in the cooler streams and ponds. In the experience of the author, Small-mouthed Bass that inhabit the streams are very difficult to catch with hook and line. I have fished for hours about their favourite holes, with the big fellows in plain sight, but it is rarely that one will bite. In the spring of 1924 I tried large white grubs among other things, and although a fish would occasionally take the bait, it would be instantly ejected again. With the other baits no interest whatever was shown.

The Small-mouthed Bass is dark or dull greenish with a lustre of gold or bronze and much mottling of darker shades. The belly is white and there are three metallic lines that extend from the eye across and beyond the cheek. In the young fishes the body often appears to be barred owing to the spotting. This species may be positively distinguished from the only other local fresh-water Bass, the Large-mouthed variety, *Micropterus salmoides* (Lacépède), by the number of rows of scales upon the cheek. In the Small-mouthed species there are about seventeen, whereas the Large-mouthed Bass has only eleven or less.

About May 20th, the nests of the Small-mouthed Black Bass may be found. In the streams the nest consists of a pebbly or sandy spot in the shallowest part of the water. A typical example found on May 19th, which was being guarded by a large fish, was close to the edge of the stream beside a large boulder that shaded the nest. The water here was one foot deep, and the eggs which were very numerous were found ad-

hering to every stone and pebble in the nest (Fig. 176). In colour the eggs are yellowish white with a more brilliant yellow yolk, and measure $2\frac{1}{4}$ millimetres in diameter.

By June 25th, the shallow parts of the inhabited stream where the water is quiet will sometimes be found swarming with fry, with the yolks still incompletely absorbed. They are very black, especially when seen through the river water, and from a distance appear like very young toad tadpoles.

The Large-mouthed Black Bass, *Micropterus salmoides* (Lacépède), inhabit lakes and large ponds, and I have never found them in any local stream. They also possess the peculiarity of entering brackish water.

In habits they are much the same as the former species, spawning in June and living a similar life. They grow considerably larger than the Small-mouthed variety and occur over a wider range.

The colour of the Large-mouthed Bass is dark dull green, somewhat lighter on the sides and toward the belly, with a silvery sheen. The young fish has a dark stripe running along its sides from the opercle to the middle of the tail.

YELLOW PERCH

Perca flavescens (Mitchill)

From the standpoint of flavour, this is the finest of the fresh-water fishes. It is easily caught on worms, minnows, or insect bait, and is found in streams, ponds, or lakes. It differs from the other worth-while local fishes in that it travels about in schools, coursing up and down the stream or about the inhabited pond.

In colour the back is olive and the sides brilliant yellow with several dark wide vertical bars. Under parts are white. The fins, with the exception of the upper ones, are red or orange, and this colouring is particularly beautiful during the breeding season, which is in April.

One of the most interesting things I ever found out, and one which I thought at the time was a discovery of my own, was the manner in which the egg strings of the Perch come about.

The tiny eggs are deposited in a mass like frogs' eggs, but this mass soon appears to unfold itself into a long ovum-studded ribbon many feet

in length! Of course, this is a well-known fact, but when one has not read of such things and finds out himself for the first time, the incident takes on all the fascination and glamour of discovery, and it is sometimes well not to read too much, lest the joy of original observation in the field be lessened.

The Perch is common and ranges in the coastal streams from Nova Scotia to Carolina and is also abundant in many parts of the West and in the Great Lakes. It is the only species of Perch in America and cannot well be confused for that reason.

CHAPTER XXVII

A WORD ABOUT SALAMANDERS

WHEN we are asked what Amphibians are, we usually answer, frogs and toads. That is correct as far as it goes, but how many of us realize that, living abundantly in our Eastern woodlands, along our streams and in our brooks and ponds, are other members of the Amphibia known as the Salamanders and Newts?

Salamanders and Newts are usually taken for lizards, but lizards belong to the order Reptilia along with the snakes and turtles. Lizards are scaly creatures with a dry skin, often living in situations of drought and sunshine that would kill and shrivel up a Salamander in an hour. The delicate little Salamanders require shady or moist situations and cannot live long if their skins become entirely dry.

Remember that in shape a Salamander resembles a lizard, but that it has a smooth skin. Also remember that frogs and toads belong to the Amphibia, but that they are tailless when full grown, whereas Salamanders are always tailed creatures. Of course, toads do not possess a smooth skin, but when I say smooth, I really mean without scales.

In Connecticut, where the author lives, there are no less than eight, possibly nine species of Salamanders, two of which are found in two distinct colour phases.

THE MARBLED SALAMANDER

Ambystoma opacum (Gravenhorst)

This creature (Fig. 177) resembles a fat, blunt-nosed, and smooth-skinned lizard, if you can imagine such a thing. It is not uncommon under logs and bark in heavily wooded country and is sometimes found in quite dry situations under stones or piled wood at the border of fields.

It is black or slaty black, patterned with irregular blotches of grayish

white and white. The under surface is bluish black. It would be difficult to confuse this Salamander with any of the other Eastern forms, if its large size, blunt appearance, and colouring are kept in mind. All the other large Salamanders which it resembles are marked distinctly with yellow.

Strange as it may appear, this species deposits its eggs in the fall instead of the spring like the rest of its relations in this locality. I have found them under slabs and stones at the edge of partly or almost wholly dried-up ponds and swamps. Here the eggs remain until the late rains fill the ponds again, when they hatch, sometimes almost as soon as thoroughly saturated.

The young, or larvæ, as they are called, are tailed creatures with gill tufts and are dull gray or mottled gray. All of their early life is spent in the water, where they feed on all kinds of small aquatic insects, mollusks, Water Asels, and other forms, emerging late in the spring to take up the adult terrestrial habitat.

THE SPOTTED SALAMANDER

Ambystoma maculatum (Shaw)

Next to the largest of the North American Salamanders, this species (Fig. 178) may always be identified at a glance by its black ground colour, and two rows of large bright yellow spots extending to the end of the tail. It is slow and sluggish by nature, and when one discovers it, by turning over a log or stone in the woods, it seldom makes any effort to get away, and allows itself to be picked up without a struggle. This species is often overlooked because of its fondness for burrowing. If the searcher, upon overturning a log, finds a small burrow, it is well to excavate this, as *maculatum* will frequently be its maker, and inmate.

Early in spring, when the water of ponds and swamps is still very cold, the Spotted Salamander deposits large masses of eggs, generally attaching them to sticks or grasses. A dozen or more masses will often be found together, probably deposited by numerous females. From April 7th on, the masses may be found. Eggs that I collected on April 10th, which were probably newly deposited, hatched on April 30th, twenty days later.

The egg mass resembles frog spawn, but it is sometimes milky, so

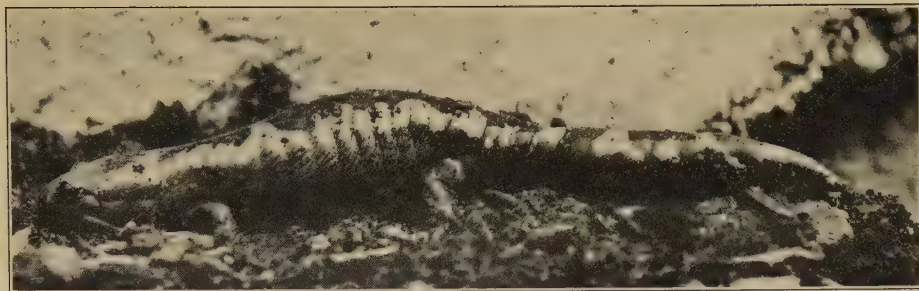


Fig. 177. The Marbled Salamander, *Ambystoma opacum*. Life size.



Fig. 178. The Spotted Salamander, *Ambystoma maculatum*. Somewhat reduced.



Fig. 179. A close-up of the head of a Spotted Salamander, considerably enlarged.
Note the blunt, fleshy toes.

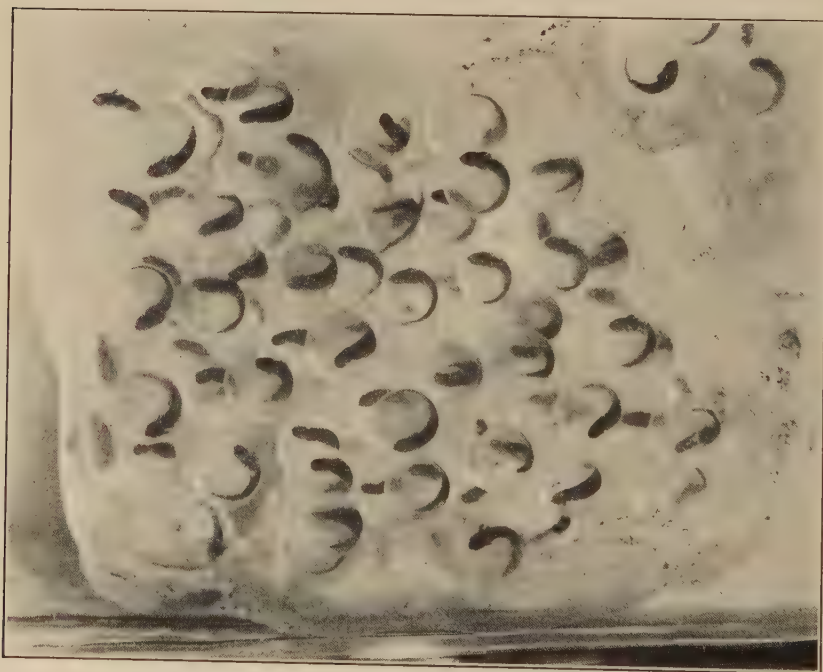


Fig. 180. Egg mass of the Spotted Salamander, showing the young with gills and fish-like characters. About life size.

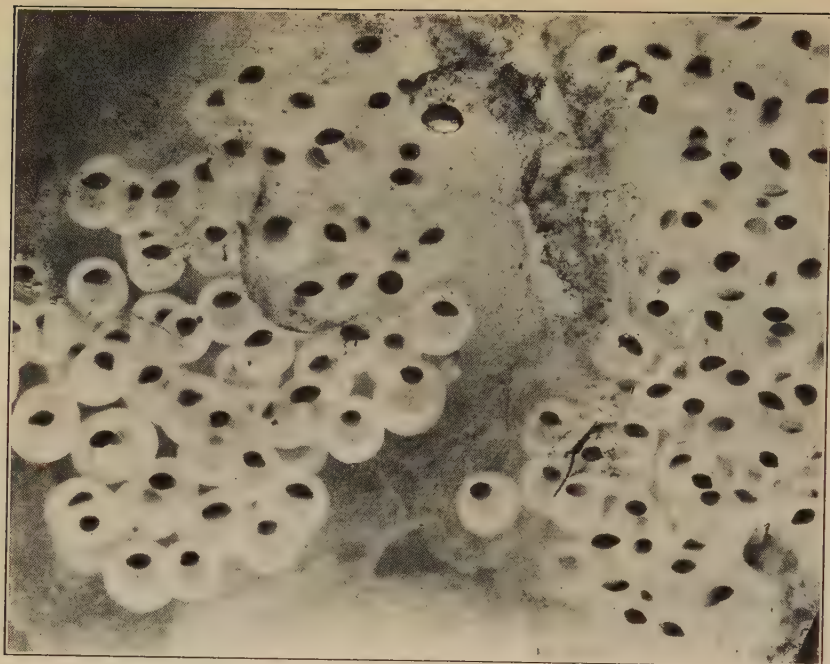


Fig. 181. Eggs of the Spotted Salamander, beginning to develop. About life size.

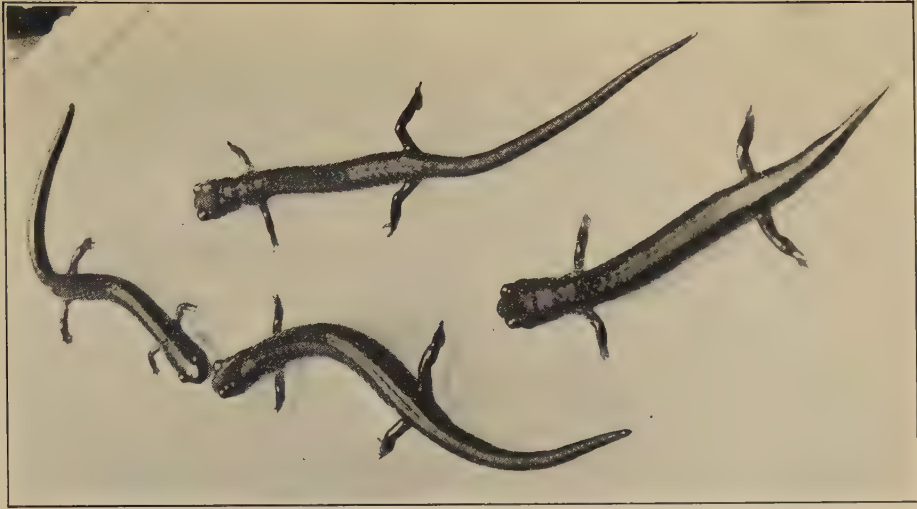


Fig. 182. Red-backed Salamanders, *Plethodon cinereus*. Life size.



Fig. 183. The Red-backed Salamander. Red phase. Much enlarged.



Fig. 184. The Red-backed Salamander. Gray phase. Much enlarged.



Fig. 185. A female Red-backed Salamander, opened to show ten developing eggs. Enlarged four times.



Fig. 186. A Salamander at home in Sphagnum Moss. This makes an excellent bedding for their cages. Much enlarged.

that the eggs within cannot be seen. It is a tough jelly studded with the egg spheres. (Fig. 181.) By squeezing one of these masses the individual eggs will pop out unbroken. They are large, measuring seven millimetres in diameter, with a clear envelope, and the forming embryo may be seen within to great advantage. (Fig. 180.) A curious feature of the life history is that often a quantity of substance resembling a green powder will be observed within the egg with the embryo. As the developing salamander moves about in its sphere, this green stuff moves around also. Under the microscope it consists of a mass of living single-celled organisms like motile Algæ. They apparently do no harm, although they feed upon the egg-jelly, and after the larvæ emerge I have had them multiply to such an extent that the entire abandoned jelly mass was reduced by them, and the jar containing the whole thing contained a sixteenth of an inch of this green culture upon its bottom, in which swarmed millions of these organisms.

The larvæ measure ten millimetres long when first hatched and bear large triple tufts of gill "feathers" on each side of the head. They are very active and ravenous feeders as they increase in size, devouring aquatic worms, Water Asels, small mollusks, and all the smaller life of their habitats. (Fig. 187.)

By July 20th they are fifty millimetres in length and the gill tufts are beginning to disappear. They are dark brown, almost black, the colour being due to myriad minute black and brown dots upon a lighter ground. Beneath they are bluish white with opaline tints.

THE FOUR-TOED SALAMANDER

Hemidactylium scutatum Tschudi

This small reddish-brown species may easily be identified, if one is so fortunate as to find it, by its bluish under surface marked with a few black dots, and by the fact that there are but four toes on the hind feet. It measures about three inches or less in length.

I have found Four-toed Salamanders under piles of big logs in the woods in August, but they are always rare in my experience. They do not move when uncovered and are therefore easily captured.

THE RED-BACKED SALAMANDER

Plethodon cinereus Green

The Red-backed Salamander (Fig. 182) is an abundant species, appearing in its characteristic habitat, under fallen bark or logs or under stones in the woods, by the 1st of April, and remaining until late in the fall. I have found it active on the 12th of March, but this is probably exceptional.

It is very variable in the colour of the stripe which runs down the centre of its back, and although this is usually more or less distinctly red, it is so obscure in some cases that the whole animal appears to be dark gray. Indeed, for a long time the gray form and the distinctly red-backed form were considered as different species. (Figs. 183 and 184.)

Eggs are doubtless deposited by this Salamander as early as April 1st and as late as July 25th, and possibly over an even longer period, as the individuals that I have dissected have contained eggs in various stages during all of this time. (Fig. 185.)

The female prepares a brood chamber under a log, the only one that I have ever found being hollowed out of soft sawdust-like material, which appeared to be the refuse left by large boring grubs of some kind.

In this chamber the eggs are deposited and guarded by the female, and the young never lead an aquatic life.

Stomach examinations brought to light the fact that these amphibians live to a considerable extent upon those primitive insects known as Collembolids. These are the Springtails that one finds so commonly in damp places almost anywhere. They are very numerous in the woods in damp leaves and moss and form an abundant source of food supply where the Red-backed Salamanders prowl about at night.

In addition to this diet, the larvæ of beetles are eaten and White Ants (*Termes flavipes*). On termites I have successfully fed these Salamanders in captivity for long periods.

All the stomachs examined also contained tiny fragments of mineral matter, which probably helps in grinding up the food.

The individual which I found on March 12th had eaten eight tiny larvæ of some insect.

Around the first week in March, I have found this species curled up and motionless under stones, and they apparently hibernate in such situations, although it seems that they might freeze so close to the surface.

THE SLIMY SALAMANDER

Plethodon glutinosus Green

Back in 1909 I found a single specimen of this interesting creature which is apparently very rare in the territory covered by this book. It was under a log in heavy hemlock woods, and I noticed at once a peculiar sticky feeling as I picked it up.

It was quite long, perhaps five inches, and its tail was cylindrical, and its body was also very round. In colour it was decidedly black, heavily sprinkled with minute silvery specks.

THE TWO-LINED SALAMANDER

Eurycea bislineata Green

This is very common under stones along the streams, preferring those that are not actually under water. It is very active and often makes its getaway despite all efforts on the part of the collector. It may be known by the yellowish band down the back with a dark band on either side. It might be confused with the Red-backed species, but these are found under logs and stones in dryer situations, are smaller, and are almost always striped with red of some shade.

On May 24th I found a batch of eggs, sixteen in number. They had been deposited in a swift-flowing sandy-bottomed brook and were attached to the under side of a broken glass dish that was slightly supported by a rim, allowing a shallow cave for them. They were just ready to hatch, and being clear, like big glass beads, the larvæ could be seen very clearly within.

Each egg was supported or fastened by a short stem of albumen, and as the eggs are elliptical, they appeared like little balloons ready to ascend. The larvæ were twelve and one half to thirteen millimetres in length, slender, and light gray, except along the abdomen, where a long yolk-

coloured mass lay within the body. The tiny eyes were distinct and quite prominent.

All were hatched by the 25th and were swimming about rapidly by wiggling their tails. They resembled tiny fishes.

When in the eggs they are curled around their interiors after the fashion of Salamander larvæ, and after the young emerge, they remain fastened to the egg for a few hours, possibly feeding upon this substance after the fashion of frog tadpoles, as the eggs shrink to about half their original size by the time the young are free. The body of the newly hatched larva is studded with tiny stars of black pigment, and along each side of the back there is a row of light dots.

The larvæ thrived in an aquarium with a few water plants, changed every few days to supply fresh food. They grew rapidly, and by June 6th the four limbs were well grown and in use for walking upon the bottom of the aquarium. The colour at this time was brownish black and the light spots were more distinct.

On June 23d the larvæ measured twenty millimetres. On June 27th I found a spring at Long Ridge filled with larvæ twenty-five millimetres in length. On July 25th the larvæ were thirty-five millimetres long and the gills were disappearing, and on July 25th, a year later, I found an individual fifty-seven millimetres long with disappearing gills. It was under a stone in the creature's mature habitat on the bank of the Rippowam. Its greater size, compared to those from the spring and my raised individuals, was probably due to living in a higher temperature and obtaining more food.

The stomach of this specimen was particularly interesting as it contained larvæ of aquatic insects and two young mollusks (young of river snail) measuring one and one-half millimetres long.

THE DUSKY SALAMANDER

Desmognathus fuscus fuscus Rafinesque

The Dusky Salamander is a moderately large species, inhabiting the borders of streams, where it hides under flat stones that rest upon sand or mud. It is a very agile creature and hard to capture unless one is in readiness as the stones are turned over. It is abundant along the Mianus



Fig. 187. The larval form of the Spotted Salamander, showing the feathery gill tufts.
Life size.

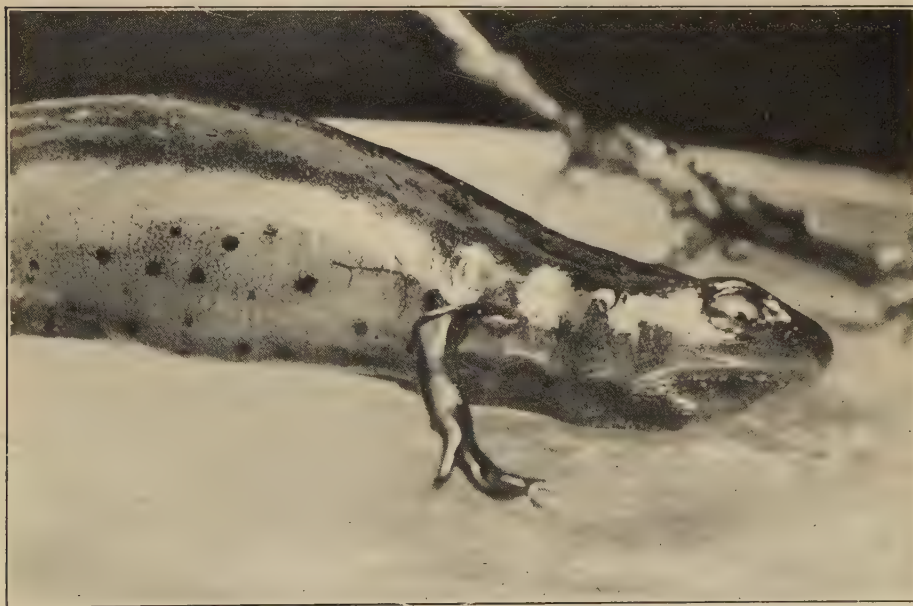


Fig. 188. A female Newt, *Notophthalmus viridescens*, showing texture of skin and spotting on under surface. Much enlarged.



Fig. 189. Front view of the American Toad, *Bufo lentiginosus americanus*. About twice life size. This is the common species of the garden that is so numerous on summer evenings. Our toads are very valuable insect destroyers.



Fig. 190. Front view of Fowler's Toad, *Bufo fowleri*. Enlarged three times. A much rarer toad than either of the two above is the Hermit Spadefoot, *Scaphiopus holbrookii*. It is nocturnal, and has webbed hind feet and *vertical* pupils.

River and is usually associated with the somewhat smaller Two-lined Salamander.

It is dark brownish black, sometimes with a reddish hue. There are numerous tiny white dots upon the sides of the body, while the belly is light in colour marked with gray. A full-grown specimen measures nearly five inches in length and may be almost black in colour.

The eggs are connected to one another by a thread of mucus, and the whole string of jelly spheres is wound about the body of the parent. Thus they are guarded until hatched.

Where the Dusky Salamander goes in winter I have been unable to ascertain, but it is my opinion that it digs itself into the bottom of the stream whose sandy banks form its summer home.

THE NEWT

Notophthalmus viridescens

The Common Pond or Water Newt (Fig. 188) was for a long time the subject of debate, owing to its various terrestrial and aquatic phases. The bright-coloured land form was called the Mountain Eft, and the larger and plainer form, the Newt.

This confusion has now been cleared up by numerous investigators who agree that the Newt passes through three stages during its life: (1) The larval stage which is spent in the water. This stage lasts from twelve to twenty weeks, and the animal is possessed of large gill tufts and a broad tail for swimming. (2) The intermediate stage, which is terrestrial and which lasts, according to different students, from two to four years. During this period the colour of the creature is beautiful brownish red, varying in brilliancy in the individual. Upon the reddish ground colour are rows of brilliant vermilion dots. (3) The final stage, which is spent in the water, the animal being of a greenish-brown colour with reddish spots and a broad swimming tail. The under surface is well dotted with black on a yellow ground.

In spring the adult form is very common in shallow ponds or pools where there is plenty of aquatic vegetation. They appear early and are very common about May 12th. In the territory covered by this book, the intermediate form is sparingly distributed in damp woods, where it

may be found under stones, bark, or logs. In one locality, however, in 1909, some three miles north of Coscob, in the woods bordering the Mianus River, I found great numbers of this beautiful Salamander. They were prowling about everywhere in the early morning after a shower. When I left my tent about 6.30 A. M., the woods were literally crawling with them.

The larval stage may be taken in large numbers in Stamford in stagnant ponds in June and during the first week in July. They are particularly abundant in Phelps' Pond about July 4th. This is a tiny stagnant pond near Glenbrook, the surface of which becomes entirely covered by Duckweed, Crystalwort, and millions of *Volvox* colonies at this season.

Several adult Newts collected on May 15th were confined in an aquarium and mated readily, the courtship of the male consisting of his stealthy approaching and gently caressing the female, rubbing her with his mouth and nose, and performing for a time quite like a cultivated lover. After a little of this, however, the female tired and made off, swimming to the top of the tank for air, when with tremendous energy and alertness he darted after her, clasping her at once in the vise of his thick and powerful legs, so tightly as to appear as if pinching her in two. In this position, the male below, they remained for a few minutes only, when each would go its own way, until the mating desire returned to the male, and he would seek another female.

On the 25th of May I found eggs in the aquarium, fastened to the leaves of water plants. Most of them were rolled up in the leaves of watercress or in blades of grass. They must have been deposited some time before I discovered them, as the embryos could be seen within the jelly spheres at this time. The eggs are oval, measuring three millimetres in length. They are transparent with a yolk which is greenish black on one side and yellow on the other.

Some of the eggs were deposited singly, and others in groups of two or three. I removed them to a finger bowl containing water and plants, and by June 1st the embryos resembled kidney beans in shape. On June 4th the larvæ were moving about within the eggs. On June 7th their tails were distinctly visible, and on June 11th hatching commenced and continued until the 15th of the month.

New-born larvæ measure six millimetres in length and are possessed of very large feathery gill tufts. They remind me of young fishes, but their tails were solid and broad and minutely speckled with black.

When the larvæ were two days old, the anterior limbs were entirely formed. The body of the larva is yellowish, studded with asteroid black pigment spots that form two rows down the centre of the head. These traverse the back and merge near the tail. This is the colouring when the young measure about eight millimetres. At three days, the posterior limbs are sprouted, and at twelve days the young Newts measured more than ten millimetres. From this time on the rate of growth is governed by temperature and food supply.

By July 29th, the larvæ of the natural ponds measure from twenty-one to thirty-five millimetres in length, and soon afterward many of them begin to exhibit the reddish colour of the terrestrial form. They are lighter than the typical land form at first, but gradually become darker, while last of all the vermilion spots and black specks appear.

As an experiment, I placed a large number of these nearly terrestrial Newts in a big aquarium. In the centre of this I floated a small island by covering a board with dirt, moss, and other growing plants. This experiment was to ascertain, or at least test, the truth of the second and third phase theory. The experiment lent weight to its correctness, for between August 8th and 14th all the young Newts crawled out upon the island, where they remained as the true land form.

They were quite brilliantly coloured at first. Some of them became more orange as time went on, and they all exhibited a distinct aversion to their late aquatic habitat.

Adult Newts hibernate in ponds, the same ones doubtless in which they breed. One finds them quite common in the fall, but none of these are ever the terrestrial phase, which must therefore hibernate in the forest.

CHAPTER XXVIII

THE FROGS AND TOADS OF THE TERRITORY

OUR frogs and toads are few in species but abundant in individuals and of very great interest. Their lives and habits are filled with surprises for the investigator, and I strongly urge the nature student to look more carefully into their biology.

In this chapter I have pointed out the main facts concerning most of the local species, but I have not told the whole story about any one of them.

At my home in Noroton, I have a small pool constructed of cement beneath the high rustic porch. The pool was finished in the month of June, and by the first of July two frogs had come by themselves to take up their abode there. A little later a third appeared, and I soon learned much of interest concerning their daily habits that I could have found out in no other manner.

The frogs were of three species—a Green Frog, a Leopard Frog, and a Wood Frog. The only pond near by is a brackish one, yet out of the night came my frogs and remained with me throughout the summer.

The most remarkable fact that I gleaned from this amphibian trio was the perfect regularity of their daily schedule. Each took up the identical hiding place through the day. Each left the pool to hunt at approximately the same time every afternoon, and each returned as soon as the sun was hot every morning. Their lives were perfectly ordered! I had always supposed that frogs led an erratic sort of life, but I soon learned that this is not so, and thus my little ornamental pool brought me valuable information.

THE AMERICAN AND FOWLER'S TOADS

Bufo lentiginosus americanus Le Conte and *Bufo fowleri* Putnam

It is, perhaps, unknown to the majority that our local fauna contains two common species of toads other than the Tree Toads. The common

toad (Fig. 189) is abundant at all times in warm weather and is the familiar species of the garden and lawn and all the cool places about the grounds that afford some protection during the day. The common toads bury themselves in the morning or hide under stones or boards, coming out in great numbers at dusk to feed until morning upon a vast variety and quantity of insects. There is no doubt in my mind that this little amphibian is of tremendous economic importance. It is interesting to note that the toad almost always comes back to the same place after its nocturnal feeding. I have often dug up the same individual day after day in the same spot in my garden, where it stayed all summer in perfect contentment, despite the endless disturbances that it was subjected to.

The American Toad may be distinguished from his close relative, or Fowler's Toad (Fig. 190), quite easily. A close study of the two enlarged views of the two species will be helpful in the first place, but it is easy to remember that Fowler's Toad is unspotted on the under surface.

If the weather is really warm, about the middle of May or even earlier, and if a good rain has fallen, the sounds of evening will sometimes be augmented by the weird and rather harsh calls of this other species. They are louder and more penetrating than the soft rolling call of the common toad, sounding to me like "Wau—K," the "Wau" being carried out as one long, slightly tremulous note, ending with a slight drop to the terminal "K."

Fowler's Toad comes to pools after rain to breed. Numbers of them were present for three years in a very small swampy place that contained water for a time after the rains of May, close by my house, which was then at Shippan Point. One also hears them at various times during the summer, especially after heavy rain in hot weather, and they are peculiar in that they may breed at various times during the year.

About the fourth of June one may hear their calling at its best, and a chorus of their wails could never be confused with the sweet singing of the American toads.

A strange fact is that Fowler's Toad comes to brackish water every year at Noroton and deposits its eggs in green *Algæ*. The eggs never appear to hatch, but in a single year breeding toads were found in this

particular place on June 1st, 5th, 8th, 9th, 12th, 15th, 16th, 21st, 22d, 23d, and 24th.

All of our toads deposit their jelly eggs in water in strings, which are wound over sticks and grass and water plants. (Figs. 191 and 192.) The jelly strings are studded with black dots, which are the yolks and which rapidly change shape and become perfectly black and flattened tadpoles. These work themselves to the outside of the jelly mass and here remain a day or two, possibly feeding upon this substance before taking up a more active life.

They grow rapidly, but development is greatly dependent upon food, temperature, and light. In a finger bowl I have raised toads that were fed on a small amount of vegetable matter of a very poor nature, such as dead leaves. In this case their growth was very slow and they did not complete their metamorphosis until very late in the year. In nature the tadpoles feed on both animal and vegetable matter.

Toads require but a few weeks ordinarily from the time the eggs are deposited until the minute but perfect amphibians leave the water. In this locality, during the first week in July, one sometimes sees the roadway or a field swarming with tiny toads. This occurs where thousands of tadpoles have become concentrated in a pool and suddenly finish their tadpole existence together, the result being a grand walk-out to pastures new. The American Toad deposits its eggs in late March and in April.

Toads possess raised glands behind the eyes that are capable of exuding a more or less poisonous secretion. This is harmless to the skin, but I have often seen my Airedale pick up a toad playfully, and then drop it in disgust, frothing at the mouth and apparently suffering some pain. It is strange in this connection that the snakes that feed upon toads are not affected. Another protective measure of the toad is to discharge a fluid from the anus when picked up, but this is also harmless to the human skin.

In winter the toads hibernate in the ground and many have been ploughed up, which shows that they do not descend to great depths. Freezing probably does not affect their health, and the degree to which they are active is controlled, as in other cold-blooded vertebrates, by temperature.

Actual stomach examinations show a great variety of food, and as the toads feed all night and sleep and digest during the day, they should be examined in the early morning. One so examined and a typical example is set out in detail below:

22 large Carpenter Ants	1 Flower Beetle
2 large-sized moth larvæ	1 Cricket
2 Sow Bugs	10 Red Ants
5 Weevils	5 Grasshoppers

Date, August 6th.

From this it is easy to realize how much good is accomplished by the great toad army in a single season. They are so numerous throughout the eastern United States that their combined efforts must be of great economic importance.

PICKERING'S TREE FROG OR "PEEPER"

Hyla crucifer Wied

Everyone knows the Spring Peeper (Fig. 193) by its voice, but, alas! how few would recognize it were it sitting calmly upon a leaf in front of their eyes!

An inch and a quarter in length, delicate, pale fawn-coloured, and bearing a more or less distinct dark cross upon its back—this is the Spring Peeper, whose loud sweet calling thrills us at the approach of spring. He has appeared in the water of the still-icy pond at the first sign of warmer days, and here in thousands the Peepers congregate to mate and the females to deposit their little jelly eggs before returning to their natural habitat among the leaves of low trees and weeds and grasses.

These little creatures are true Tree Frogs, and an examination of the tips of their tiny toes will reveal the small suction disks with which they are fitted for climbing.

The Peepers deposit their eggs singly or in small groups, and the life history of the tadpole is much the same as that of the other frogs.

They are, of course, much smaller and more delicate than the young Bullfrogs and Pond Frogs, and doubtless serve as the food of a large

number of preying aquatic insects. Water Tigers, which are the young of the big black Water Beetles, are particularly fond of them, and a large toll is also taken by the dragon-like young of the Darning Needles.

THE COMMON TREE FROG

Hyla versicolor Le Conte

This species (Fig. 195) may always be identified locally as follows: When full-grown it is two inches in length and has large round suction disks on the ends of its toes. The only other local frog fitted with these climbing disks is the Spring Peeper, but this species is never more than an inch and a quarter in length and has a distinct cross upon its back.

The common Tree Frog is variously coloured according to the conditions surrounding it. It may be brown or gray or green, and is always banded and marked with dark colour, although this is sometimes very faint. The under parts are light, with considerable orange-yellow toward the rear.

We all know the Tree Frog by its song if not by sight, and its gentle calling before and after a shower seems almost to be a part of the storm, so closely are the two associated. These highly beneficial, insect-eating animals live in the trees throughout the summer. Only in the spring do they change their mode of existence, and at this time they go to the ponds to mate and deposit their eggs. They remain in the water but a short time and are soon in their arboreal haunts again. Even in winter, when these Frogs are hibernating in the mould of some limb or trunk, they are still Tree Frogs in every sense of the word. They disappear for their winter sleep in September and reappear at apple-blossom time, when breeding commences, and by June 4th most of them have ascended the trees again.

When a Tree Toad is calling in the daytime, it is very difficult to locate and will usually stop singing as one approaches. At night, however, when the frogs are calling to their mates in the pond or in the bushes close by, one may walk right up to them with a flashlight and easily capture the singers. At this time, their calling is impassioned and different in quality from the usual sleepy call of summer.

The eggs may be found in May in small bunches near the top of the pond, and occasionally eggs are deposited singly. They are attached to



Fig. 191. Jelly egg strings of the American toad may be found in March and April.

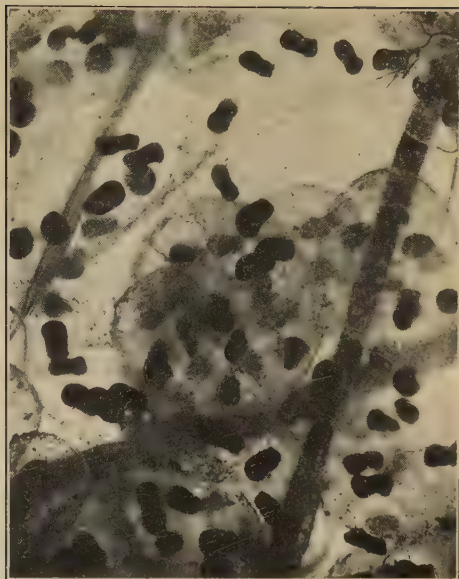


Fig. 192. Enlarged view of toad's eggs with developing tadpoles.



Fig. 193. The Spring Peeper, *Hyla crucifer*. Side view, enlarged four times.



Fig. 194. Very young tadpoles of the Wood Frog. These tads have only recently left the eggs. Much enlarged.



Fig. 195. The Common Tree Frog, *Hyla versicolor*. Side view. Enlarged about twice. They are sometimes brilliantly patterned as shown here.

grass or water plants. They hatch very quickly, and in a very undeveloped state, but from this time on the development is very rapid, so that in three weeks the four legs are developed and in four or five weeks the new Tree Frog is about a finished product.

When first hatched the tadpoles are yellowish, but as they grow older they become dark, with an almost iridescent sheen, while the borders of the tail become quite orange and the eyes are red.

When the young frogs leave the water, they are brilliant green, and the stub of the tail is not absorbed for some days after this event. In the late larval stage they measure twenty-seven millimetres, and after the tail is absorbed, sixteen millimeters. Some of the tads, especially when on a sandy bottom, display a mottled coloration that is quite protective. The new froglet has gold eyes with black pupils. The dark bars appear soon after the tail is absorbed, and the green colouring then becomes less brilliant. The larvæ may be found in various stages until well into the summer and they are still transforming every day around the end of July. The bright green young ones may be collected by sweeping a butterfly net through the bushes around the pond or swamp

THE LEOPARD AND PICKEREL FROGS

Rana pipiens Shreber and *Rana palustris* Le Conte

These two frogs are easily confused, but may be distinguished as follows.

The Leopard Frog (Fig. 197) may be green or brown, with two rows of rounded dark spots along its back and two rows of such spots along each side. Its under parts are white or slightly yellowish.

The Pickerel Frog is brown with two rows of distinctly squarish spots along its back and two rows of other spots along each side. The under parts are white in front, and there is a brilliant mixture of yellow and orange toward the lower parts of the body.

The Leopard and Pickerel Frogs spend most of their time out of water. They are true hunters and wander considerable distances from the ponds. They will be found in grassy meadows, in ferns, and even in the woods where there is a heavy growth of small plants that afford sufficient shade and moisture.

They feed on all sorts of insects, including caterpillars, and in captivity will also take worms.

The eggs are deposited in water like those of all our frogs, and the development is rapid, which is doubtless due to the fact that they are not found in the ponds until the water is fairly warm. At such times, the food supply is also more abundant, which, of course, is conducive to rapid growth.

THE GREEN FROG

Rana clamitans Latreille

The Green Frog (Fig. 198) might be easily confused by the uninitiated with the Bullfrog, but may be distinguished easily enough by its more metallic quality, which never shows in the latter. Besides this, its head is very much thicker, and the hind feet are not as fully webbed.

The sexes may be identified by the fact that the ear of the male is much larger than the eye, whereas that of the female is either smaller or about the same size as the eye. The throat of the male is orange-yellow.

This frog is common throughout eastern North America and is the one that utters a loud alarm note as it leaps from the brook bank into the shelter of the water.

The eggs are deposited early in the spring in compact masses and are usually attached to a stick or bit of grass under the water. The tadpoles are light in colour and require two seasons to metamorphose into frogs.

Green Frogs may be kept in captivity very easily and will feed greedily upon earthworms. They should be kept in an aquarium or cage, with all-glass sides. If wire is used the frogs will injure themselves about their heads, and once the skin becomes broken it is difficult to heal it. Much of interest may be learned from such pets, and one of the most interesting of their habits is that of casting the skin, a process which they undergo several times a year.

THE WOOD FROG

Rana sylvatica Le Conte

This most beautiful and intelligent of our Eastern Frogs is the first to appear in the woodland pools in spring. (Fig. 196.)

It hibernates under stones in the woods, sometimes under very flat ones, so that little protection from temperature is afforded. Here it sleeps in a sort of cell which it forms about its body from the surrounding earth or mould. I have found it thus upon turning over stones on sunny woodland hillsides. It comes back to active life about March 25th except in unseasonable weather.

The first warm day, toward the end of March—and we always get one or two of these—a din of Wood Frog voices will be heard in the shallow leafy-bottomed pools that are to be found so commonly and that later dry up.

Mating takes place at once, and afterward the pool appears to be deserted immediately by the frogs, that is to say, as soon as the eggs are laid. Eggs are found commonly by April 10th or a little later, attached to sticks or grass in the water. The egg masses are rounded and contain many hundred eggs. These consist of transparent jelly spheres seven millimetres in diameter with a velvety black yolk two millimetres in diameter. This yolk increases in size as development goes on, and becomes partly lighter in colour.

The eggs hatch in different periods according to the temperature of the water.

Batches collected on April 10th and kept in glass jars at the outside temperature, hatched on April 17th. These individuals were beginning to lengthen out within the eggs by April 12th. On the 15th, their gills were visible and they moved occasionally, but did not actually leave the eggs until the 17th, after having been attached to the jelly mass for a few hours after breaking out of the capsules. (Fig. 194.)

Growth is rapid, but depends to a great extent upon the food supply. Thus individuals from a brood that were fed on animal matter grew one third as fast again as the remainder of the brood, which were fed on vegetable substances.

The former were eleven millimetres in length on April 24th, fifteen millimetres on April 30th, and twenty-two millimetres on May 24th.

By June 15th, tiny perfect froglets are leaving the woodland pools to take up their terrestrial lives.

THE BULLFROG

Rana catesbiana Shaw

This is the last of the frogs to come from its winter sleep in the bottom of the pond or stream. In the territory covered by this book they usually appear between May 10th and June 1st, according to the temperature and the weather.

Most of us are familiar with the species, but it is easily identified by its colour, which is a solid green or greenish brown *without* a metallic quality. It is sometimes spotted with dark colours and the legs are also spotted and barred with brown. In the male, the ear is larger than the eye, and the throat is yellow. In the female, the eye and the ear are about the same size. The ear is the large round object just back of the eye of a frog. The Bullfrog might be confused with the Green Frog, but the latter is metallic green or metallic greenish brown on the head and shoulders, shading into olive and often spotted with darker colours toward the tail-end. In addition, the Bullfrog may be known by the fully webbed hind foot and its wide and very flat head.

They are the most ravenous feeders of the frog tribe, devouring the larvæ of aquatic beetles and Dragon Flies, worms, fishes, flying insects, other frogs, young ducks, and other young water birds. A huge individual that I kept in a cage for an entire summer devoured all his cage mates. Many of these were moderately large Green Frogs, and the powers of digestion exhibited by this particular frog were truly remarkable.

There is no sweeter sound in nature than the deep "Jug o' rum" of the Bullfrog as it floats to us from the distant pond on a summer night. I associate this sound with Fireflies and the perfume of late June and the sensation of ecstasy that comes with the arrival of summer evenings.

We all know this sound, and for a long time I believed that this peaceful calling in the frog's delicious basso was its only vocal offering. How mistaken I was, but how hideous is the other voice that I have learned to know! It issues from the creature when it is in fear of death. It is a terrifying scream, pitched high, blood-curdling, human, and ghastly. What the Bullfrog's enemies are I cannot say exactly, possibly hawks, or mink, or skunks. Whatever they may be, they must know this awful scream,



Fig. 196. The Wood Frog, *Rana sylvatica*. Much enlarged. This is the brown or cocoa-coloured frog of the woods. There is a much darker patch about the ear, bordered by a light line as shown above.

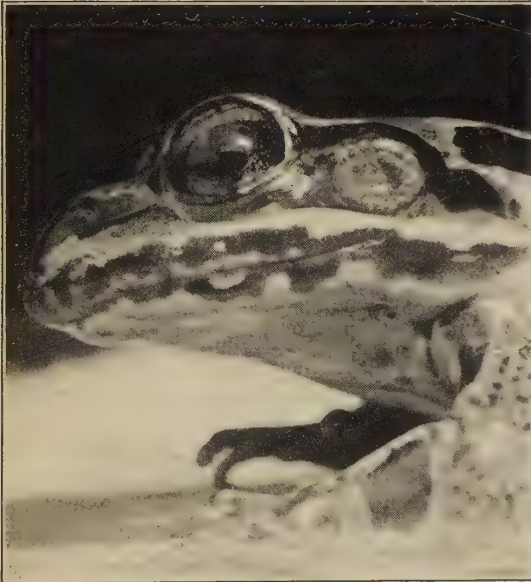


Fig. 197. The Leopard Frog, *Rana pipiens*. Enlarged three times. This species lives in long grass as much as it does in the pond.



Fig. 198. Green Frog, *Rana clamitans*. Much enlarged. A very common frog distinguished from the Bullfrog by its metallic sheen.

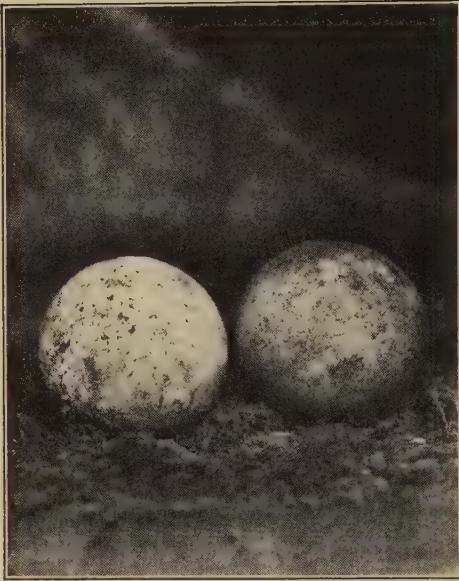


Fig. 199. Eggs of the Snapping Turtle. Not quite life size.



Fig. 200. Eggs of the Painted Terrapin. Not quite life size.

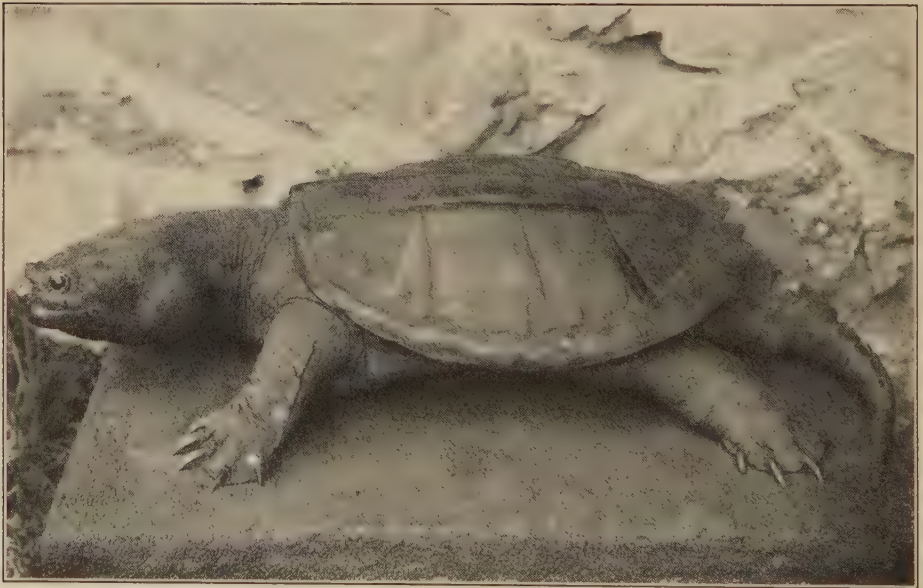


Fig. 201. The Snapping Turtle, *Chelydra serpentina*. This huge specimen was found in the Rippowam River. From a mounted specimen in the Bruce Museum at Greenwich.



Fig. 202. The Painted Terrapin, *Chrysemys picta*. Two thirds life size.

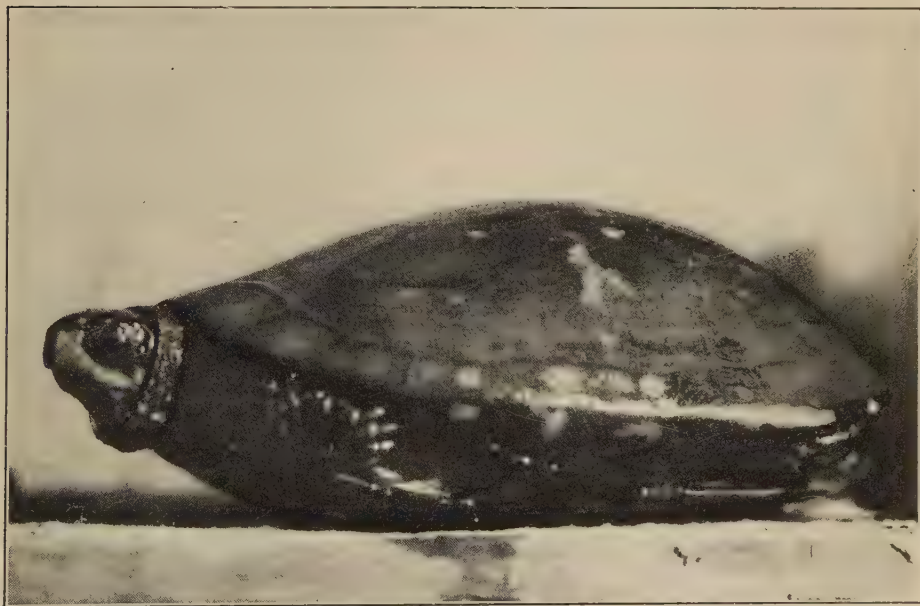


Fig. 203. The Spotted Turtle, *Chelopus guttatus*. Two thirds life size.



Fig. 204. Eggs of the Spotted Turtle. They are deposited in late August. Rule shows natural size.



Fig. 205. Embryo of turtles removed from the eggs. Left, Painted Terrapin. Right, Wood Turtle. Enlarged twice.

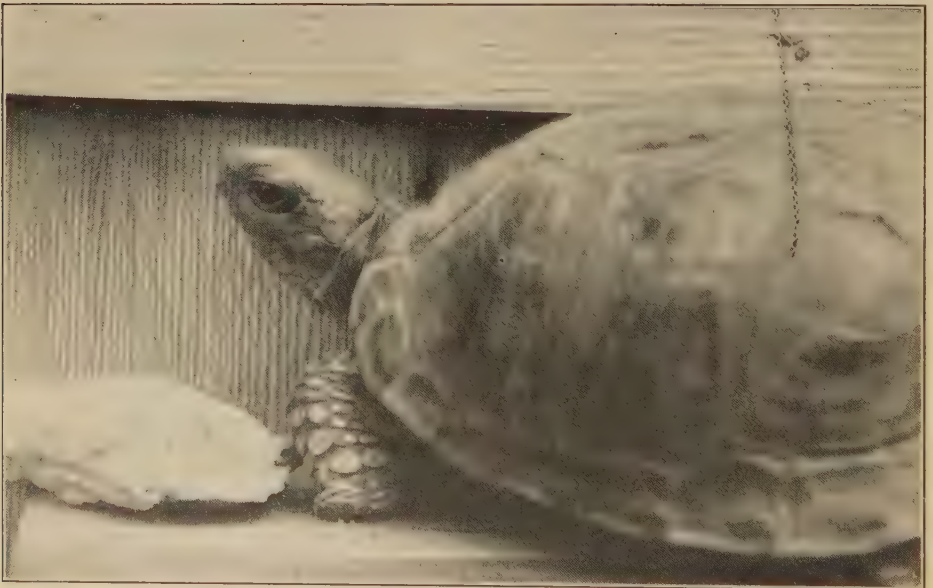


Fig. 206. The Wood Turtle, *Chelopus insculptus*. It is shown one half natural size.

which we may hear, if we care to, by capturing a Bullfrog suddenly and squeezing him hard. Once heard it will never be forgotten.

Bullfrogs are late breeders, and their tadpoles do not grow into adult frogs until the second season. They are very large tadpoles by the time they are nine or ten months old and are excellent pond scavengers, feeding upon animal and vegetable matter alike.

When young, they possess many aquatic enemies, and these are often the very creatures upon which they themselves will feed when reigning over the pond as full-grown frogs.

CHAPTER XXIX

OBSERVATIONS ON TURTLES

IN THE territory covered by this book there are six species of turtles, all of which are easily identified. The largest is the common Snapping Turtle, *Chelydra serpentina* (Linn.), which inhabits our streams and the more sluggish ponds and lakes. They grow to a great size and reach a weight of thirty-five pounds or more with a carapace measuring fourteen or fifteen inches in length. (Fig. 201.)

These dull brown turtles are common enough, but are often passed by as projecting stones or hummocks of mud, for their rough shells certainly resemble these. The great powerful head and mandibles and the deeply serrated carapace or shell will at once identify the species in the eastern United States.

Snappers are ravenous feeders, catching and devouring fish and frogs and even young water fowl, and they spend much of their time under the water crawling along the bottom in search of other things to eat.

In the summer the female turtle leaves the water and digs a hole, into which the perfectly white, round eggs are deposited. Here they are abandoned, but covered with dirt, and the young turtles shift for themselves as soon as they reach the light of day. (Fig. 199.)

An uncommon turtle, which I have only found inhabiting the Mianus River, is the Musk Turtle, *Aromochelys odoratus* (Latr.). As its name implies, it possesses a strong odour of musk, and may be identified by this odour. This species is dull brown and the shell sometimes appears greenish, which is due to Algæ growing upon it. There are two yellow stripes on each side of the head.

It is a small species, measuring three or four inches in length, and it seldom leaves the water of its chosen stream except for the purpose of depositing its eggs.

I have found quite a number of Musk Turtles in the Mianus River

near Coscob, Connecticut, but strange to say, no other local stream or lake has yielded a single specimen.

This species might be confused with the common Mud Turtle, *Cinosternum pennsylvanicum* (Bosc.), but this last turtle has a brownish head spotted with yellowish markings, and it does not appear to be living in the territory covered by this book.

The most beautiful and common species is the Painted Terrapin, *Chrysemys picta* (Herm.). (Fig. 202.)

Its carapace is olive-brown bordered with peculiar crimson and black markings on both the upper and lower surfaces. The plastron, or bottom section of the shell, is yellow, and the head and neck are striped and spotted with yellow also. Length four to six inches.

It is very common in ponds, less so in streams, and is often to be seen in company with Spotted Turtles, basking in parties upon a stone or log.

The eggs are white and elongated, with a fairly tough shell, and are buried in soft warm ground by the parent in July. (Fig. 200.)

The Spotted Turtle, *Chelopus guttatus* (Schneider), is our commonest species. (Fig. 203.)

In early spring it makes its appearance about the ponds and brooks and may be seen sunning itself on any warm day. A brook or pond of any size is suitable for the needs of this species. I have picked up a dozen along the banks of a tiny trickling brooklet in a few minutes, and have seen them crowded upon a fallen log in the centre of a pond in the woods.

Spotted Turtles are black, with numerous and irregular round yellow spots upon their shells and some yellow marking upon the under side of the carapace and upon the plastron. The head is also spotted with yellow.

Like all our turtles, this species lays eggs. They are deposited in late August and are rather hard-shelled and oval in shape. (Fig. 204.)

We now come to our two species of land turtles. One of these, the Wood Turtle, *Chelopus insculptus* (Le Conte), is not common, although I usually run across one or two each season. (Fig. 206.)

The carapace measures six inches or more in length and is brown. The separate plates are marked with yellow lines and spots. On its under edge, the carapace is yellow and black. The plastron is also yellow with black

markings on the individual plates, and the skin that is visible between the carapace and the plastron is in many places a beautiful red.

The Wood Turtle frequents the land most of the time, and it is found in open woods. It feeds upon berries, insects, and fungi, and will eat lettuce or other green stuff in captivity.

The near relative of this species and one that is more frequently met with is the Box Turtle, *Gistudo carolina* (Linn.). It may be identified by its high rounded carapace and the fact that its plastron, or lower shell, is hinged, so that the animal may draw in its head and, by closing this hinged portion, obtain complete protection.

The shell is blackish brown or brown, with many yellow spots and blotches. The plastron may be black or brown, spotted with yellow or unspotted. The male's eyes are red and the female's more yellow or orange.

The Box Turtle is quite common in open woods and is often killed when crossing public roads. It comes from hibernation in dry ground early in the spring in an emaciated condition that contrasts sharply with that of the fat bulging turtle of late fall. Its food consists of berries and other vegetable matter and some insects. I have fed them in captivity successfully upon worms.

The eggs are oval, and are buried in the ground by the parent, but I have never seen a young one.

It is a strange fact that few people have ever found them, and records are scarce. Why this should be so is indeed a mystery, for the old turtles are not at all rare. I have kept them in captivity and have secured the eggs, but none of these ever developed embryos.

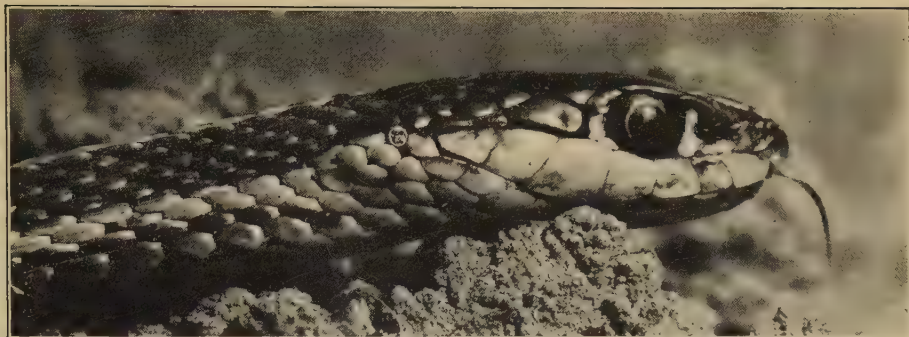


Fig. 207. Ribbon Snake, *Eutania saurita*. Note that the yellow stripe is on the third and fourth rows of scales above the abdominal plates. This distinguishes the species from the commoner Garter Snake, which has the yellow stripe on the second and third rows. Enlarged three times.



Fig. 208. The Water Snake, *Tropidonotus fasciatus sipedon*. Somewhat reduced. These are vicious reptiles, striking at their captor in an angry manner. They are non-poisonous, however.

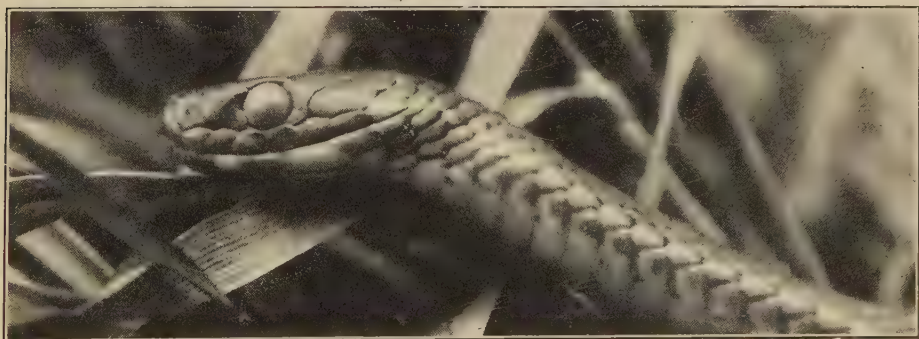


Fig. 209. Brown Snake, *Storeria dekayi*. These delicate little creatures come into the cellars of our houses in winter. It is shown here three times its natural size. They are absolutely harmless and will not bite.



Fig. 210. The Blacksnake, *Zamenis constrictor*.

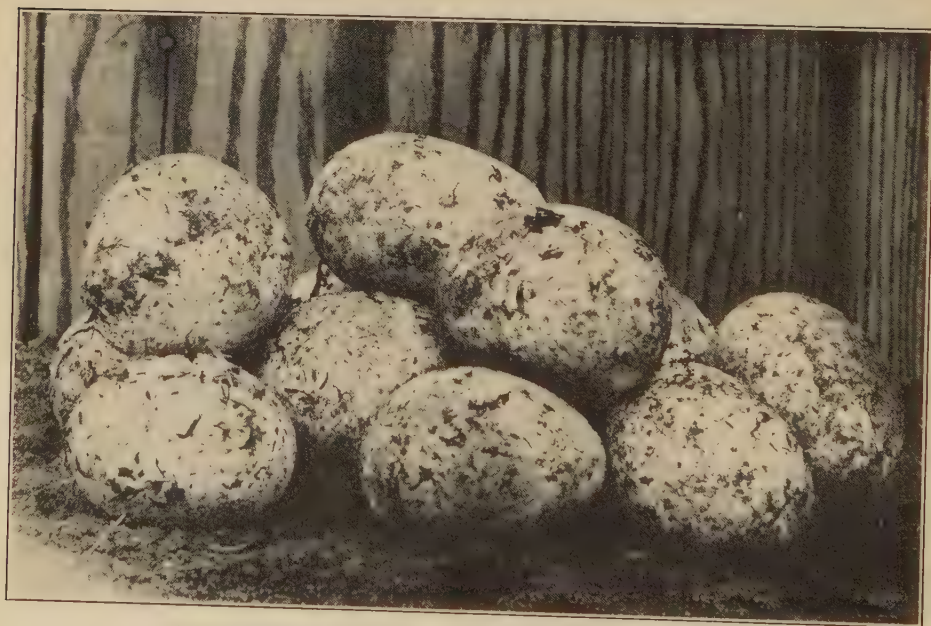


Fig. 211. Eggs of the Blacksnake. Somewhat reduced.

CHAPTER XXX

SNAKES, FAMILIAR AND OTHERWISE

TWELVE species of snakes inhabit the small circle of territory included in this book, and some of these are reptiles with wide ranges. One does not realize how common snakes are until a deliberate effort is made to study them, and then they may be found easily and in considerable numbers.

Of the striped snakes, Genus *Eutænia*, we have two distinct species which are almost always confused by the layman and by many of those who profess a knowledge of such things. These are the Garter and Ribbon snakes, *Eutænia sirtalis* (Linn.) and *Eutænia saurita* (Linn.) (Fig. 207.) Any snake found here with a dark body and three yellowish or greenish stripes is either of these two, and the two species are easily distinguished by the position of these stripes.

In the Garter Snake, the side stripes are on the second and third rows of scales above the abdominal plates, while in the Ribbon Snake they are placed upon the third and fourth rows. The stripes of this last species are a brilliant yellow, and the reptile is slimmer and more delicate.

Everyone knows the Garter Snake, which is the most abundant of our serpents. It inhabits gardens, woods, stream borders, walls, meadows, and, in fact, every place in which its widely varied menu may be obtained. Its cousin is scarce in this locality, but when found is invariably near water, where it loves to feed upon tadpoles and young frogs. It is more aquatic than the Garter Snake and appears to be at home in the water. The Garter Snake feeds upon tadpoles, toads, frogs, and a wide variety of insects. It is also very fond of earthworms.

Both of these species are viviparous, but the Ribbon Snake gives birth to much smaller litters than the Garter Snake. A Ribbon Snake dissected in late July contained only ten embryos. Its cousin may contain as many as sixty or more.

An interesting case that caused great interest at the Bruce Museum during the summer of 1922 was that of a Garter Snake that became a mother twice within a week. On August 15th her first litter of thirty appeared in the cage, and on the morning of the 20th, thirty-three more were born, so that in all there were sixty-three young ones. They swarmed about the mother and produced a very unusual sight that brought hundreds of visitors to the Museum. All of the young snakes were in good health but five. Three of these were born dead and the other two were curiously deformed, their bodies being fused in such a manner that they could not move about. They fed readily and fought violently over their allotments of earthworms, and occasionally the mother would take a hand, or I should say mouth, and swallow the worm and young one together. At night the young snakes coiled about the old one, literally hiding her from view—which she did not appear to mind.

In giving birth to young, the Garter Snake extrudes each one separately in the form of a ball, rather flattened. This is a sac within which the young one is coiled and from which it bursts in a few minutes possessed of all its faculties.

In fall, Garter Snakes congregate, sometimes in large numbers, at their wintering places, usually where there are piled-up rocks and broken soil and numerous deep cracks and crevices into which they may go. As the days get cold, they appear less and less, until finally they remain below until the warmth of the following spring awakens them to active life again.

A ball of these hibernating snakes was found here some years ago in the rotten pulp in an old hollow apple tree.

Garter Snakes are not poisonous, but will strike and fight bravely when captured. Their teeth are very sharp and cut with the ease of a razor blade, but they may be handled safely by placing a stick or one's foot upon the reptile's neck, after which it may be picked up with the thumb and forefinger at the base of its head.

The Water Snake, *Tropidonotus fasciatus sipedon* (Linn.), is the only one of the genus *Tropidonotus* that we have to deal with. Often called Water Moccasin and considered highly dangerous by laymen this vicious but non-poisonous species is usually left strictly alone. (Fig. 208.)

It is brown or reddish brown marked, with irregular bands of dark brown on the forward part of the body and spots or blotches of the same colour on the hind part. The under side is spotted with black and bright red. Length three to four feet.

Young snakes are gray, banded with black, with black spotted under parts, and are born alive, toward the end of the summer.

The Water Snake lives along the edges of streams and about the edges of ponds, where its natural food of frogs, tadpoles, and fish is easily obtained, and where it may take refuge in the water at the approach of an enemy. Water Snakes are not uncommon, but being very swift-moving reptiles, are difficult to capture, unless found just after coming from hibernation.

Two diminutive reptiles of the genus *Storeria* inhabit this territory. One is the Brown Snake, *Storeria dekayi* (Holbrook) (Fig. 209), and the other the Red-bellied Snake, *Storeria occipitomaculata* (Storer).

Neither of them ever attains a length of more than a foot, and indeed all those that have been observed by the author have been well under that length. The Brown Snake is much commoner than the Red-bellied Snake, and is found in dry situations, about old walls, in sandy roadways, and often comes into cellars in the fall to pass the winter.

This harmless and docile little snake is light brown, with a paler line running down its back. This is bordered with small black dots. The under surface is white, tinted with pink.

The young are born alive and are of various shades of gray, some being almost black, and each is ornamented with a lighter-coloured ring about its neck.

I have fed the old snakes in captivity upon earthworms, and this is doubtless their natural food. They are easily fed and tamed and make excellent little pets.

The Red-bellied Snake resembles the Brown Snake in colour and size, but its under parts are brilliant red. There are also four yellow spots upon the neck. The young are much like those of its near relative, but perhaps generally darker. In habits it is also much the same as the Brown Snake, but, as I have said before, it is not nearly as numerous and is infrequently met with.

Of the Racers, genera *Spilotes* and *Zamenis*, I have found but a single representative, and this is the big familiar Blacksnake, *Zamenis constrictor* (Linn.). (Fig. 210.)

Everyone in the country knows the Blacksnake of the thickets and weed-bordered stone walls. He always makes himself known by his rapid and decided retreat the instant one of his human enemies comes within sight. Along the walls and their accompanying growth, this species finds food and shelter in profusion, and that is the chief reason for its love of this habitat.

The Blacksnake is slaty black above, but is sometimes confused with the Pilot Blacksnake, which belongs to another genus. The latter is beautiful, almost glossy black, white under the chin and throat, and gray to white over the remainder of the belly. The Blacksnake is white only on the chin and throat.

Young specimens are entirely different, being light gray, with brown blotches and black spots at the sides.

Blacksnakes feed upon mice, birds' eggs, and young birds and frogs. I have found them twenty feet up in trees hunting for nests. One snake was coiled about a wood thrush's nest with a fledgling in its mouth. In captivity they are easy to keep and require very little feeding. They reach a total length of six feet, but this is unusual. The usual length is from five to five and one half feet.

Eggs are deposited in June and July. One set containing fifteen dug up in soft soil measured from thirty to forty-two millimetres in length. (Fig. 211.) They are elongate with a white leathery shell covered with small rough scales or flakes which do not overlap. Their skin or shell resembles the skin of certain puffballs. They hatch about two months after they are deposited.

The measurements of the set of eggs mentioned above were as follows:

1.	30 millimetres	6.	34 millimeters
2.	31 "	7.	34 "
3.	31 "	8.	35 "
4.	33 "	9.	35 "
5.	34 "	10.	35 "



Fig. 212. Greatly enlarged photograph of a Blacksnake's egg, cut open to show the coiled-up young one within.



Fig. 213. The Green, or Grass Snake, *Liopeltis vernalis*. About twice life size. This species is pale green.

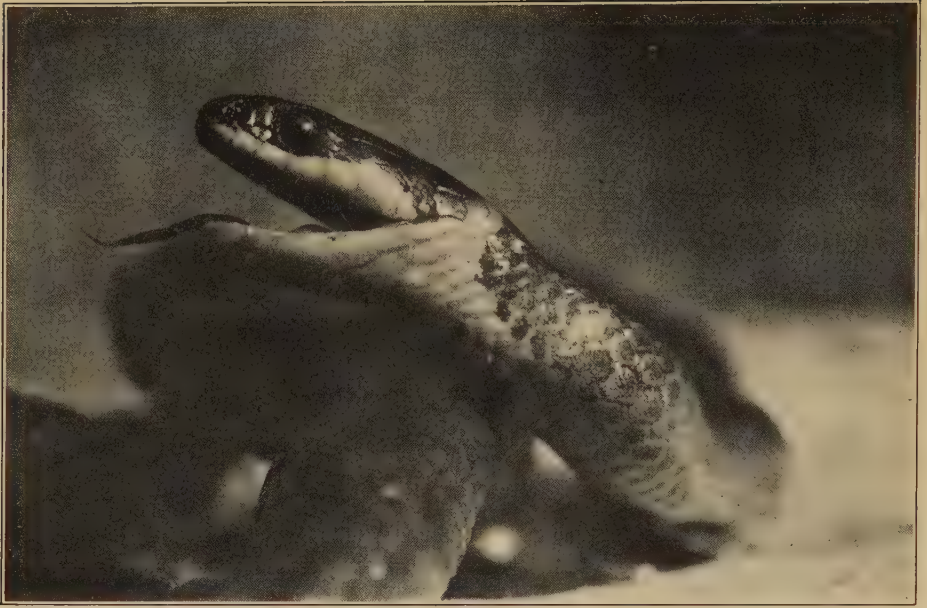


Fig. 214. The beautiful Ring-necked Snake, *Diadophis punctatus*, may be found only by the patient searcher. Much enlarged



Fig. 215. Immature Hog-nosed Snake, *Heterodon platyrhinus*. Its turned-up nose identifies it. It is shown here about one half life size.

11.	36 millimeters	14.	40 millimetres
12.	37 “	15.	42 “
13.	40 “		

Average, 36.27 millimetres.

As time goes on, the eggs lose their even contour, become larger, and take on peculiar forms, many of which are more or less angular. They will hatch very successfully if kept in damp Sphagnum Moss, or the soft rotten pulp from old tree cavities is equally good. At birth the young snakes are eight inches or more in length.

The Pilot Blacksnake, *Coluber obsoletus* (Say), already mentioned, belongs to another genus as will be readily seen by its name.

It is found here, but much more rarely than the Blacksnake.

The most beautiful of our snakes belongs to the genus *Liopeltis*. It is the Green Snake or Grass Snake, *Liopeltis vernalis* (De Kay). (Fig. 213.)

It is very uncommon in the experience of the author, but may occasionally be met with in grassy fields or low bushes. I found one in a tangled thicket by the roadside.

It is a beautiful pale green upon the upper surface and very pale greenish upon the belly.

This species deposits a small cluster of elongated eggs in late summer, hiding them under a sheltering stone or bit of bark. The young are “very dark olive above and greenish white below” (Ditmars).

This delicate creature is an insectivorous species, preying upon caterpillars, spiders, and small, more or less smooth-bodied, insects. It is very docile and easily handled, and so delicate and beautiful that it is a joy to possess one even if only for a few minutes of close observation.

Another snake of great beauty which is only found by the patient searcher is the Ring-necked Snake, *Diadophis punctatus* (Linn.). (Fig. 214.) The length of an average full-grown specimen is about fourteen inches, but some reach more than nineteen. They are light gray above and yellow underneath, with a brilliant yellow ring around the neck. This beautiful snake may always be known by the yellow ring and belly and its glossy appearance. It is rather uncommon in the Stamford region, being found chiefly in the more hilly country. It hides under stones

and bark that has fallen to the ground, and slab piles left by portable sawmills are particularly good hunting grounds for this serpent. It is harmless and timid and may be handled without fear.

Individuals that I kept at the Bruce Museum in Greenwich, in a terrarium with small salamanders, ate these batrachians with great relish, particularly the Red-backed species. This may form a usual article of their diet, as a specimen caught by Mr. Charles Howes and presented to the author disgorged a Red-backed Salamander soon after being captured. Besides this diet, like most of our snakes, the Ring-neck is fond of earthworms.

Eggs are deposited in June and July in small batches. They are long and narrow, becoming much longer and of greater diameter near hatching time. Forty-five days are required to bring forth the young, which are very dark coloured and hatch without any care from the parent.

The Ring-necked Snake comes out early in the spring, as early as April 10th, or in other words as soon as its favourite victims, the Red-backed Salamanders, are common in their usual habitats.

The King Snakes, genus *Ophibolus*, are represented in our fauna by the Milk Snake, or Checkered Adder, *Ophibolus doliatus triangulus* (Daudin).

The Milk Snake is a beautifully marked reptile, with its gray back, over which are set numerous brown saddles which appear to be resting upon little black saddlecloths whose edges may be seen protruding beyond them. The under parts are white, spotted and marked with black. The young snakes are similar to the old ones, but the colouring is more vivid, especially as regards the brown and black saddles and their cloths.

The species is oviparous, depositing a small cluster of elongated eggs.

Milk Snakes are fond of hiding away. I have found them under large flat stones or boards and under an old tent floor that had been left by the campers when they departed from their site in a field near the woods.

It is a beneficial snake, feeding upon mice, and it should be given the fullest protection. A full-grown specimen appears to be slightly more than three feet in length, as I have never seen one any larger.

A heavy-bodied snake with a turned-up snout and a habit of flattening itself and hissing loudly is the Common Hog-nosed Snake, *Heterodon platyrhinus* (Latreille). (Fig. 215.) It is harmless, but appears to the un-

initiated as a poisonous and dangerous reptile. In colour it is variable. It may be yellowish brown, or reddish brown, with large dark-coloured patches all over the back which are surrounded by the ground colour and therefore very distinct. Its turned-up snout is its best identification mark.

The food of the Hog-nosed Snake consists chiefly of toads, although frogs are accepted by it.

In the summer, it deposits a few elongated eggs, but I have never seen the young when first born. When ten or twelve inches in length they look much like the old snakes. A full-grown specimen may be two or three feet in length, and the body is thick and rather flat. The head is more or less triangular, which adds to the illusion of the snake being a dangerous one.

Our only dangerous and poisonous species in the territory of this book is the Copperhead, *Ancistrodon contortrix* (Linn.), which is one of the Moccasins.

Contrary to the general belief, the Copperhead is not uncommon in the wilder country of the Ridges some miles from the centres of civilization.

I have found and captured several specimens at Long Ridge, Connecticut, where they inhabit the deciduous woods, especially where a portable sawmill has been at work and a pile of sawdust and slabs has accumulated.

At first sight, the snake will sometimes glide away, but at other times it will remain motionless as though conscious of its deadly powers. Thus I caught one several years ago that was lying coiled in a woodpath directly in front of me. When it was captured, I allowed it to sink its teeth into a bit of soft wood, and as it withdrew them from the pith, two droplets of yellow, oily venom remained where they had entered. The Copperhead's venom is virulent and deadly, and the hunter of snakes should learn to recognize this species.

This snake is brown, with large cross-bands of deeper and richer brown, which are narrow on the middle of the back but broaden out very much on the sides. The under parts are pinkish or reddish, with two rows of dark-coloured spots. The snakes are not large, two or two and a half feet being the usual length.

The species is viviparous, giving birth to small litters of young. A specimen that I had at the Bruce Museum for an entire summer gave birth to six, and to my surprise the tips of their tails were bright yellow!

It has been suggested that this tail so closely resembles a yellow grub that it might be used by the partly concealed snake to attract small frogs. Whether this is so or not I cannot say for sure, but it is very likely to be, and it will be an interesting and valuable observation for whoever is fortunate enough to prove it.

THE END

INDEX

- Acadian Flycatcher, 1.
 Acarus, 127.
Acmæa albeus, 69.
 testudinalis, 69.
 Adder's Tongue, 21.
Alectrion obsoleta, 71.
 Alewife, 143, 144.
 Algæ, Filamentous, 160.
 motile, 175.
 Alternation of generation, 46.
Ambystoma maculatum, 174, 175.
 opacum, 173, 174.
Ameiurus melas, 159.
 nebulosus, 159.
 Ammogoronne, 10.
 Amœboid Protozoa, 142, 156.
Ancistrodon contortrix, 201.
 Anemone, 21.
 Angler, 151.
Anguilla chrisypa, 135.
 Animalcules, Wheel, 156.
 Ants, Army, 103.
 battles of, 101.
 Carpenter, 133.
 cattle tending of, 102.
 feeding of, 87.
 how to study and photograph, 86.
 human side of, 101.
 meat-packer, 101.
 Mound, 103.
 robber, 103.
 Ant Lions, 118.
Apeltes quadracus, 150.
 Aphididæ, 96, 102, 122, 123, 131.
Aplexa hypnorum, 64.
 Arachnida, 76.
 Argonaut, 75.
Aromochelys odoratus, 192.
 Arrowheads, Siwanoy, 13.
 Asel, Water, 35, 36, 55, 56.
Asellus communio, 55.
 Assassin Bugs, 124.
 Aster, New England, 25.
Asterias forbesii, 48.
 vulgaris, 48.
Aurelia flavidula, 47.
 Back Swimmers, 123.
 Bacteria, rearing, 28, 29.
Balanus balanoides, 51.
 eburneus, 51.
 Baltimore Oriole, 21.
 Barn Swallow, 21.
 Barnacles, Goose, 50.
 Ivory, 50.
 Rock, 50.
 young of, 51.
 Bass, Large-mouthed Black, 171.
 Small-mouthed Black, 170.
 Basswood, 23.
 Beach Flea, 55.
 Bedbug, 123.
 Bees, Bumble, 129.
 food of young, 129.
 Honey, 129.
 Leaf-cutter, 129.
 Beetles, June, 127.
 Lady, 126, 132.
 Potato, 126.
 Rove, 126.
 Water, life history of, 112.
 Bergall, 139.
 Bird-lice, 121.
 Black Duck, 25.
 Blackbird, Red-winged, 20.
 Black-crowned Night Heron, 18.
 Black-nosed Dace, 161.
 Blacksnake, 198.
 Blue and Yellow Dauber, life history of, 105.
 Bluebird, 19.
 Bluebottle fly, 125.
 Bluefish, 142.
 Blue-winged warbler, 1, 21.
 Boat Shell, 70.
Boleosoma nigrum olmstedii, 165, 166.
 Book-lice, 121.
 Bot Fly, 125.
 Box Turtle, 194.
Brevoortia tyrannus, 138.
 Brown Snake, 197.
 Bugs, Assassin, 124.
 Bed, 123.
 Chinch, 123.

Bugs—Continued.

- Flat, 123.
- Leaf, 123.
- Plant, 123.
- Squash, 123.
- Stink, 123.
- Thread-legged, 123.
- Water, 123.
- Bufo fowleri*, 183.
- lentiginosus americanus*, 182.
- Bullfrog, 190.
- Bullhead, Black, 159.
- Bumblebee, 129.
- Butterfly, Baltimore, 21.
 - Grapta comma*, 20.
 - Milkweed, 24.
 - Mourning Cloak, 20.
 - Tailed Blue, 23.
 - Tiger Swallowtail, 21.
 - Wood Nymph, 22.
- Cabbage, Skunk, 19.
- Caddice Fly, 119.
- Caddice Worm, 119.
- Cake Urchin, 49.
- Callinectes sapidus*, 54.
- Cancer borealis*, 54.
- Carcinides mænas*, 54.
- Cardinal Flower, 24.
- Cassiterite, 4.
- Catbird, 21.
- Caterpillar, Tent, parasite of, 22.
- Catostomus commersonii*, 164.
- Centipedes, 78.
- Cephalopoda, 75.
- Cercopidæ, 122.
- Chalcid flies, 128.
- Charicium longipes*, 160.
- Checkered Adder, 200.
- Chelopus guttatus*, 193.
- insculptus*, 193.
- Chelydra serpentina*, 192.
- Cherry, Choke, 29.
- Chicadee, 19.
- Chilopoda, 78.
- Choke Cherry, 24.
- Cicadellidæ, 123.
- Cinquefoil, 21.
- Cirripedia, 50, 51.
- Cistenedes gouldii*, 48.
- Chinch Bug, 123.
- Chlorion ichneumonea*, 23.
- Chogset, 139.
- Cholera, Chinch-bug, 94.
- Chrysemys picta*, 193.
- Chub, Common, 163.
- Cicadas, 122.
- Cinosternum pennsylvanicum*, 193.
- Cistudo carolina*, 194.
- Cladocera, 36.
- Clam, Hard-shell, 74.
 - Razor, 74.
 - Soft-shell, 74.
- Clupea harengus*, 143.
- Coccidæ, 123.
- Cochineal*, 123.
- Coleoptera, 126.
- Coluber obsoletus*, 199.
- Comb-jellies, 47.
- Common Tern, 24.
- Cones, glacial, 8.
- Copepods, parasitic, 138.
 - pink, food of Stickleback, 149.
- Copperhead, 201.
- Coral, Elkhorn, 46.
- Corrodentia, 129.
- Coscob, 16.
- Cowbird, 20.
- Crab, Blue, 54.
 - Fiddler, 54.
 - Green, 54.
 - Hermit, 55.
 - Horseshoe, 57.
 - Jonah, 55.
 - King, 57.
 - Lady, 55.
 - Oyster, 55.
 - Spider, 56.
- Crane fly, 125.
- Crangon vulgaris*, 52.
- Creeper, Virginia, 24.
- Crepidula fornicata*, 70.
 - plana*, 70.
- Crested Flycatcher, 22.
- Crickets, 120.
- Crocus, 20.
- Crow, American, 19.
 - Fish, 1.
- Crustacea, 50.
- Crystalwort, 33, 34.
- Ctenophora, 47.
- Cuttlefish, 75.
- Cyanea arctica*, 47.
- Cyclops, 40.
- Cyprinidæ, 158.
- Damsel Fly, 117.
- Daphnia, 36.

- Darning Needle, 117.
 Darter, Tessellated, 165, 166.
 Decapods, 75.
 Dermaptera, 120.
Desmognathus fuscus fuscus, 178, 179.
 Devilfish, 75.
Diadolphis punctatus, 199.
 Diatoms, *Ceratoneis*, 56.
 Charicum, 160.
 Closterium, 23, 38.
 Cyclotella, 56.
 Diatoma, 56.
 Docidium, 56.
 Epithemia, 56.
 Gomphonema, 56.
 Nitzschia, 56.
 Differentiation, Law of, 43.
 Diffugia, 161.
 Diplopoda, 78.
 Diptera, 125, 126.
 Dobson Fly, 118.
 Dogwood, 25.
 Dominica, worm capsules found in, 44.
 Dove, Mourning, 21.
 Downy Woodpecker, 20.
 Dragon Flies, 117.
 Duck, Black, 25.
 Golden-eye, 19.
 Duckweed, 33.
 Dusky Salamander, 178.
Dytiscus harrisii, life history of, 112.

 Earwig, 120.
Echinarchnius parma, 49.
 Eel, Common, 125-138.
 Eel Grass, 24.
 Elder, 20.
 Elderberry, 24.
 Elm, 20.
Empusa musca, 94.
 English Sparrow, 19.
Ensis directus, 74.
Esox lucius, 168.
 reticulatus, 167, 168.
Eupleura caudata, 71.
Eupomotis gibbosus, 169, 170.
Eutania saurita, 195.
 sirtalis, 195.

 Fallfish, 162, 163.
 Finch, Purple, 19.
 Fish flies, 118.
 Fish Hawk, 24.
 Fish moths, 116.
 Fishes, fresh-water, 157-172.
 salt and brackish water, 135-157.
 Flagellate Protozoa, 160, 167.
 Flat bugs, 123.
 Flatfishes, 146.
 Fleas, 126.
 Flesh flies, 125.
 Flies, Bluebottle, 125.
 Caddice, 119.
 Chalcid, 128.
 Crane, 125.
 Damsel, 117.
 Dobson, 118.
 Dragon, 117.
 Fish, 118.
 Flesh, 125.
 Fruit, 125.
 Ichneumon, 128.
 House, 125.
 Lace-winged, 118.
 May, 116.
 Robber, 125, 133.
 Salmon, 117.
 Saw, 128.
 Scorpion, 119.
 Stone, 117.
 Syrphus, 133.
 Flounders, Summer, 146.
 Winter, 146.
 Flycatcher, Acadian, 1.
 Crested, 22.
 Least, 35.
 Foraminifera, 142.
 Formicaries, 86.
 Four-eyed fish, 153.
 Four-toed Salamander, 175.
 Frog, Bull, 190.
 Green, 188.
 Leopard, 187.
 Pickerel, 187.
 Pickering's, 185.
 Tree, 186.
 Wood, 188.
 Frog-fish, 151-153.
 Frog-hoppers, 122.
 Frostfish, 140.
 Fruit flies, 125.
Fulgur canaliculata, 72.
 carica, 72.
Fundulus diaphanus, 163.
 heteroclictus macrolepidotus, 154.
 Fungi, rearing minute, 30.

- Gall Insects, 127.
 Gall Mites, 127.
 Garnet, 4.
 Garter Snake, 195.
 Gasteropoda, 62.
Gasterosteus bispinosus, 147-150.
 Gastrotricha, 40.
 Gentian, 26.
 Glaciation, 6.
 Golden-crowned Kinglet, 21.
 Golden-eye Duck, 19.
 Golden-eyed Lace-wing Fly, 118.
 Goldenrod, 24.
 Goldenrod Gall, 128.
 Goldfinch, 24.
 Grackle, Purple, 20.
 Grass, Eel, 24.
 Grasshoppers, 120.
 Gray Squirrel, 19.
 Great Blue Heron, 20.
 Green Frog, 188.
 Green Heron, 21.
 Green Snake, 199.
 Grosbeak, Rose-breasted, 22.
 Grouse, Ruffed, 19.
 Gull, Herring, 24.

Haminea solitaria, 69.
 Harvestman, 76.
 Hawk, Fish, 24.
 Red-shouldered, 20.
Hemidactylium scutatum, 175.
 Hemiptera, 123, 124.
 Heron, Black-crowned Night, 18.
 Green, 21.
 Great Blue, 20.
 Herring, Branch, 144.
 Common, 143, 144.
 Herring Gull, 24.
 Heterocera, 124.
Heterodon platyrhinus, 200.
 Heteroptera, 123, 124.
Hippocampus hudsonius, 145, 146.
 Histogenesis, 99, 100.
 Histolysis, 99, 100.
 Hog-louse, Water, 35, 36, 55, 56.
 Hog-nosed Snake, 200.
Homarus americanus, 52.
 Homoptera, 122.
Hormidium nitens, 156.
 Honeybee, 129.
 Honey-dew, 123.
 Hornets, 129.
 Hornyhead, 161, 162.

 Horse flies, 125.
 House Fly, 125.
Hybopsis kentuckiensis, 161.
Hydra viridissima, 35.
 Hydracarina, 165.
 Hydractinia, 53.
 Hydroids, marine, 45.
 Fresh-water, 35.
Hyla crucifer, 185.
 versicolor, 186.
 Hymenoptera, 128.
 Hyperparasitism, 78, 92.

 Ichneumon flies and wasps, 128.
Idya roseola, 47.
 Indians, Mohican, 16.
 Rippowam, 16.
 Siwanoy, 10.
 Insects, ancestor of, 97.
 characteristics of, 115.
 fungal diseases of, 94.
 how to photograph, 80.
 nerve-winged, 118.
 number of, 116.
 outlines of life histories of, 115-130.
 parasites of, 90.
 Scale, 123.
 spittle made by, 123.
 Insect association on a rose bush, 131-134.
 Iron pyrites, 4.
 Isoptera, 121.
 Ivy, Poison, 26.

 Jellyfish, Comb, 47.
 Common, 47.
 Sun, 47.
 Jonquil, 20.
 Junco, 19.
 June Bug, 127.

 Katydid, 120.
 Kettles, glacial, 8.
 Killifish, 154.
 Fresh-water, 163, 164.
 Kinglet, Golden-crowned, 21.
 Kitchen middens, Siwanoy, 11-16.

 Ladybugs, 126.
 Lamellibranchiata, 62.
 Leaf-bugs, 123.
 Leaf-cutter Bee, 129.
 Leaf-hoppers, 122.
 Least Flycatcher, 25.

- Least Sandpiper, 24.
 Leopard Frog, 187.
 Lepidoptera, 124.
Lepomis auritus, 168.
Lernæenicus radiatus, 138.
Libinia dubia, 54.
 emarginata, 54.
 Lilac, 22.
Limax agrestis, 67.
 Maximus, 68.
 Lomonite, 4.
 Limpets, 69.
Limulus polyphemus, 57.
Liopeltis vernalis, 199.
Littorina littorea, 70.
 obtusata palliata, 70.
 rudis, 70.
 Lobster, 52.
 Locust Tree, 22.
Loligo Pealei, 75.
Lophius piscatorius, 151-153.
Lumbricus fætoides, 41.
 terrestris, 41.
Lymnæa columella, 62.
 palustris, 62.
 Mallophaga, 121.
 Mantids, 120.
 Maple, 20.
 Marbled Salamander, 173.
 May Flies, 116.
 Meadowlark, 19.
 Mealy-bugs, 122.
 Mecoptera, 119.
 Medusæ, 45.
 Megachile, 128.
 Megalops, 55.
 Megaloptera, 118.
Melampus lineatus, 71.
Mellita testudinata, 49.
 Membracidae, 122.
 Menhaden, 138.
Menidia menidia notata, 141.
Microgadus tomcod, 140.
Micropterus dolomieu, 170.
 salmoides, 171.
 Midges, 125.
 Milk Snake, 200.
 Millipedes, 78.
 Mites, water, 165.
Modiola modiolus, 73.
 plicatula, 73.
 Mole cricket, 121.
 Mollusks, breathing of terrestrial, 66.
 distribution of, 61.
 byssus of, 73.
 food of, 61, 67.
 fresh-water, 62.
 Gasteropod, method of feeding, 69.
 link between aquatic and terrestrial, 67.
 marine, 68.
 terrestrial, 66.
 young of bivalve, 65.
Monobia quadridens, 23.
 Mosquitoes, 125.
 Mossbunker, 138.
 Moth, Cotton-worm, 25.
 Fall Canker-Worm, 26.
 Io, 22.
 Moths, 124.
 Mourning Dove, 21.
 Moulds, rearing of, 28, 29.
 Cladosporium, 30.
 Monilia sitophila, 29.
 Mucor, 30.
 Pencililium, 30.
 Mud Turtle, 193.
 Mummychog, 154.
 Musculium, 65.
 Mushrooms, 25.
 Musk Turtle, 192.
 Mussels, fresh-water, 64.
 salt-water, 72, 73.
Mya arenaria, 74.
Mytilus edulis, 73.
 pellucidus, 73.
Natica heros, 69.
 Nauplius, 50.
 Nautilus, Paper, 75.
 Nereidæ, 48.
Nereis pelagica, 48.
 Nerve-winged insects, 118.
 Nesting boxes, wasp, 97.
 Neuroptera, 118.
 New England Aster, 25.
 Newt, Water, 179.
 Nighthawk, 25.
Notophthalmus viridescens, 179.
 Nuthatch, White-breasted, 19.
 Octopi, 75.
 Odonata, 117.
 Odynerus, 100.
 Old Hardy, 17.
 One-quart world, primary life of, 33.
Ophibolus doliatus triangulus, 200.

- Orchard Oriole, 1.
Orchestia agilis, 55.
 Oriole, Baltimore, 21.
 Orchard, 1.
 Orion, 26.
 Orthoptera, 120.
Osmerus mordax, 140.
 Ostracoda, 34.
Ostrea virginica, 73.
Ovalipes ocellatus, 54.
 Owls, 26.
 Oyster, 73.
 Oyster drill, 71.

Pagurus longicarpus, 53.
 pollicaris, 53.
 Painted Turtle, 193.
 Paper Wasp, 129.
Paralichthys dentatus, 146.
 Parasites, of aphids, 90.
 butterflies' eggs, 91.
 Cabbage Butterfly, 91.
 Pigeon Tremex, 92.
 Sceliphron cementarium, 91.
 Partridge-berry, 26.
Pecten irradians, 73.
 Peeper, 185.
 Pelecypoda, 72.
Penæus brasiliensis, 52.
 Pequot Swamp, 16.
Perca flavescens, 171.
 Peripatus, 97.
 Periwinkle, 72.
 Pewee, Wood, 24.
 Pheasants, 21.
 Phœbe, 20.
 Phycodromidæ, 19.
Physa ancillaria, 65.
 gyrina, 64.
 Pickerel, common, 167.
 Pickerel, Frog, 187.
 Pigeon Tremex, 128.
 Pike, 168.
 Pill-bug, 55.
 Pilot Blacksnake, 199.
 Pine Siskin, 19.
Pinnotheres ostreum, 54.
 Pipefish, 144.
 Pisidium, 65.
 Planorbis, exacuuous, 63.
 parvus, 63.
 trivolis, 63.
 Plant bugs, 123.
 Plant-lice, 122, 131.

 Planulæ, 45.
 Plecoptera, 117.
 Plectoptera, 116.
Plethodon cinereus, 176.
 glutinosus, 177.
Pleurosigma attenuatum, 149.
 Pluteus, 49.
Polygyra albolabris, 66.
 thyroides, 66.
Pomatopus saltatrix, 142.
Pomolobus pseudoharengus, 144.
 Ponus Sagamore, 16.
 Potato Beetle, 126.
 Potholes, glacial, 9.
 Pottery, Siwanoy, 12.
 Privet, 23.
Pseudopleuronectes americanus, 146.
 Pulmonata, 66.
 Purple Finch, 19.
 Purple Grackle, 20.
 Pyralidæ, 22.

Rana catesbiana, 190.
 clamitans, 188.
 palustris, 187.
 pipiens, 187.
 syloatica, 188.
 Red-backed Salamander, 176.
 Red-bellied Snake, 197.
 Red-breasted Bream, 168.
 Red-eyed Vireo, 22.
 Redpoll, 19.
 Red-shouldered Hawk, 20.
 Redstart, 25.
 Reduvids, 123.
 Red-winged Blackbird, 20.
Rhinichthys atronasmus, 161.
 Rhopalocera, 124.
 Ribbon Snake, 195.
 Ring-necked Snake, 199.
 River, Byram, 2.
 Mianus, 1.
 Mill, 1.
 Noroton, 1.
 Rippowam, 1.
 Rivulus, 153.
 Roaches, 120.
 Robber flies, 125.
 Robin, 19.
 Rock, Asbestos-hornblende, 2.
 Feldspar, 2.
 Feldspathic granite, 2.
 Gneiss, 2.
 Granite, 2.

Rock—Continued.

- Granite-gneiss, 2.
- Hornblende, 2.
- Hornblende-schist, 2.
- Limestone, 2.
- micaceous, 2.
- porphyritic, 2.
- Talc, 2.
- Rock-shelters, Siwanoy, 16.
- Rose-breasted Grosbeak, 22.
- Rose Chafer, 127.
- Rove Beetle, 126.
- Rubbing-stones, Siwanoy, 13.
- Ruffed Grouse, 19.
- Sagamore, Ponus, 16.
- Salamander, Dusky, 178.
 - Four-toed, 175.
 - Marbled, 173.
 - Newt, 179.
 - Red-backed, 176.
 - Slimy, 177.
 - Spotted, 174.
 - Two-lined, 177.
- Salmon flies, 117.
- Salvelinus fontinalis*, 166.
- Sand-collars, 70.
- Sand-dollars, 49.
- Sand-hoppers, 55.
- Sandpiper, Least, 24.
 - Spotted, 21.
- Sapsucker, Yellow-bellied, 26.
- Sawflies, 128.
- Saxifrage, 21.
- Sea Horse, 144.
- Segmentian armigera*, 63.
- Semotilus atromaculatus*, 163.
 - corporalis*, 162.
- Scale insects, 122.
- Scallops, 73.
- Scarabs, 127.
- Sceliphron cementarium*, life history of, 105.
- Scorpion flies, 119.
- Scrapers, Indian stone, 16.
- Scutigera forceps*, 79.
- Shad Bush, 21.
- Shellac, 123.
- Ship Worm, 75.
- Shrew, Short-tailed, 19.
- Shrimp, Edible, 52.
 - Sand, 52.
- Siphunculata, 122.
- Siskin, Pine, 19.

- Skunk Cabbage, 19.
- Slimy Salamander, 177.
- Slugs, 67.
 - obtaining shells of, 68.
- Smelt, American, 140.
 - Sand, 141.
- Snails, Land, 66.
 - Pond, 62.
 - River, 64.
- Snake, Black, 198.
 - Brown, 197.
 - Copperhead, 201.
 - DeKay's, 197.
 - Garter, 195.
 - Grass, 199.
 - Hog-nosed, 200.
 - Milk, 200.
 - Pilot Black, 199.
 - Red-bellied, 197.
 - Ribbon, 195.
 - Ring-necked, 199.
 - Water, 196.
- Snapjacks, 127.
- Snappers, 142.
- Snapping Turtle, 192.
- Song Sparrow, 19.
- Sow-bug, 55.
- Sparrow, English, 19.
 - Song, 19.
 - White-throated, 19.
- Spearing, 142.
- Spex urnaria*, 23.
- Spiders, *Argiope riparia*, 107.
 - Argiope transversa*, 107.
 - camouflaged, 77.
 - Eperia trifolium*, 107.
 - Epeira trivittata*, 107.
 - Enemies of, 78.
 - Lycosid, 77.
 - Misumena aleatroia*, 107.
 - Phiddipus multiformis*, 107.
 - Tarantula, 76.
 - young of, 77.
- Spirobolus marginatus*, 78.
- Sporotrichum globuliferum*, 94.
- Spotted Salamander, 174.
- Spotted Sandpiper, 21.
- Spotted Turtle, 193.
- Springtails, 116.
- Squash bugs, 123.
- Squid, 75.
- Squirrel, Gray, 19.
- Staphylinidæ, 126.
- Starfishes, 48.

Sticklebaek, Four-spined, 150.

Two-spined, 147-150.

Stink-bugs, 123.

Stone flies, 117.

Storeria dekayi, 197.

occipitomaculata, 197.

Succinea ovalis, 66.

Sucker, Common, 164.

Suctoria, 126.

Sumac, 23.

Sunfish, Common, 169.

Sunjelly, 47.

Swallow, Barn, 21.

White-bellied, 21.

Symbiosis, 54.

Symmetry, Law of, 43.

Syngnathus fuscus, 145.

Syringa, 22.

Syrphus americanus, 133.

Tagelus gibbus, 74.

Tarantulas, 76.

Tautoglabrus adspersus, 139.

Tent Caterpillar, parasite of, 22.

Termes flavipes, 176.

Tern, Common, 24.

Terrapin, Painted, 193.

Thread-legged Bug, 123.

Thysanoptera, 122.

Thysanura, 116.

Tibicen sayi, 122.

Tibicina septendecim, 122.

Tin, 4.

Toad, American, 182.

Fowler's, 183.

Tomcod, 140.

Toredo navalis, 75.

Tortricidæ, 128.

Trachynema digitale, 46.

Tree Frog, Common, 186.

Pickering's, 185.

Tree-hoppers, 122.

Tremex columba, 128.

Trichoptera, 119.

Trillium, Purple, 21.

Tropidonotus fasciatus sipedon, 196.

Trout, Eastern Brook, 166.

True flies, 125.

True lice, 122.

Truncatulina, 156.

Turtle, Box, 194.

Mud, 193.

Musk, 192.

Painted, 193.

Turtle—Continued.

Snapping, 192.

Spotted, 193.

Wood, 193.

Two-lined Salamander, 177.

Uca minax, 54.

pugilator, 55.

pugnax, 55.

Unio complanatus, 64.

Urosalpinx cinerea, 71.

Venus mercenaria, 74.

Violets, 21.

Vireo, Red-eyed, 22.

White-eyed, 1, 21.

Virginia Creeper, 24.

Volvox, 36, 37.

Walking Sticks, 120.

Warbler, Blue-winged, 1, 21.

Redstart, 25.

Yellow-breasted Chat, 1.

Wasps, aphid killing, 132.

Blue and Yellow Dauber, 105.

Chalcid, 128.

Chlorion ichneumonea, 23.

food of social, 129.

food of solitary, 106.

Ichneumon, 128.

Monobia quadridens, 23.

Odynerus, 100.

Paper, 129.

pupation of, 110.

Sceliphron cementarium, 105.

Spex urnaria, 23.

young of solitary, 98.

Water Boatmen, 123.

Water Bugs, 123.

Water Flea, 36.

Water mites, 123.

Water Snake, 196.

Water Striders, 123.

Water Tiger, life history of, 112.

Weevils, 127.

Wheel Animalcule, 156.

White ants, 121.

Witch-hazel, 26.

White-bellied Swallow, 21.

White-breasted Nuthatch, 19.

White-eyed Vireo, 1, 21.

White-throated Sparrow, 19.

Wood Frog, 188.

Woodpecker, 20.

Wood Pewee, 24.

- Wood Turtle, 193.
Worms, Caddice, 119.
 Clam, 48.
 Earth, 41.
 reproduction of, 44.
 Ship, 75.
Wren, Carolina, 4.
 House, 21.
 Winter, 26.
Yellow-bellied Sapsucker, 25.
Yellow-breasted Chat, 1.
Yellow Jacket, 129.
Yellowlegs, 25.
Yellow Perch, 171.
Zamenis constrictor, 198.
Zones, life, 1.
Zygoptera, 117.?

